THE PRODUCTION ENGINEER

JANUARY 1960

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THE PRODUCTION ENGINEER

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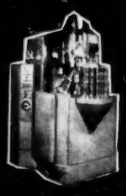

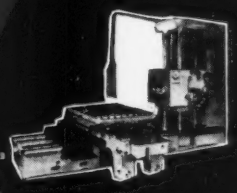

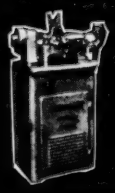

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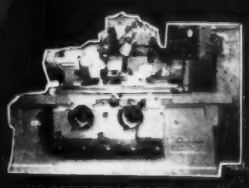

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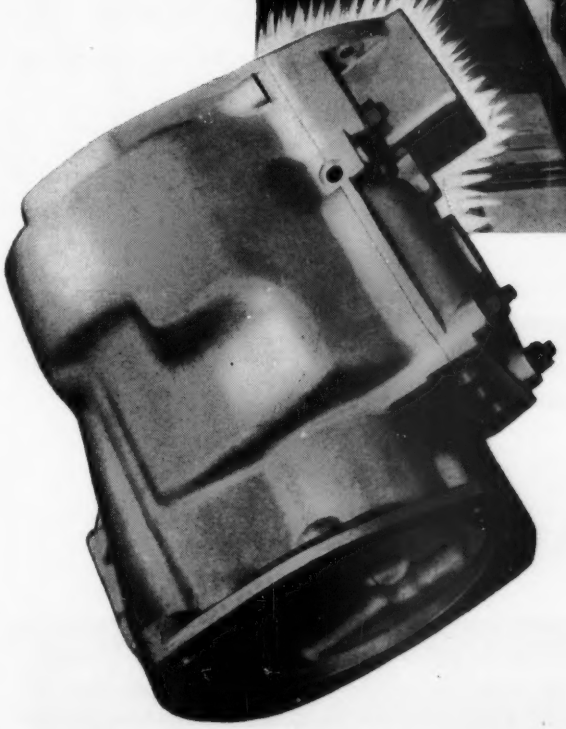

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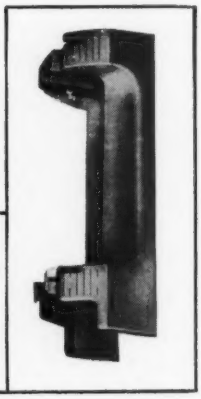

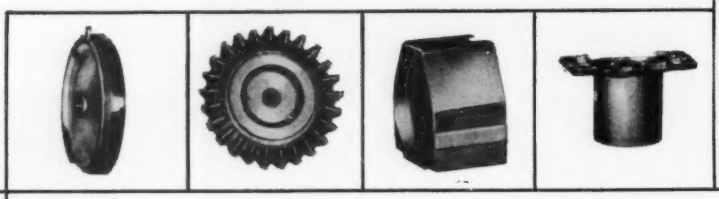

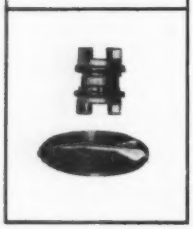

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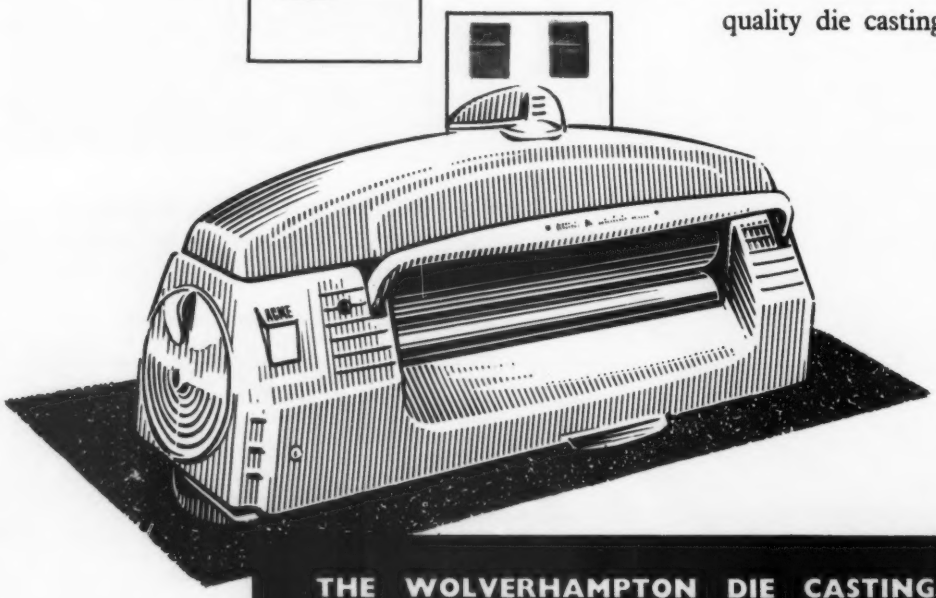

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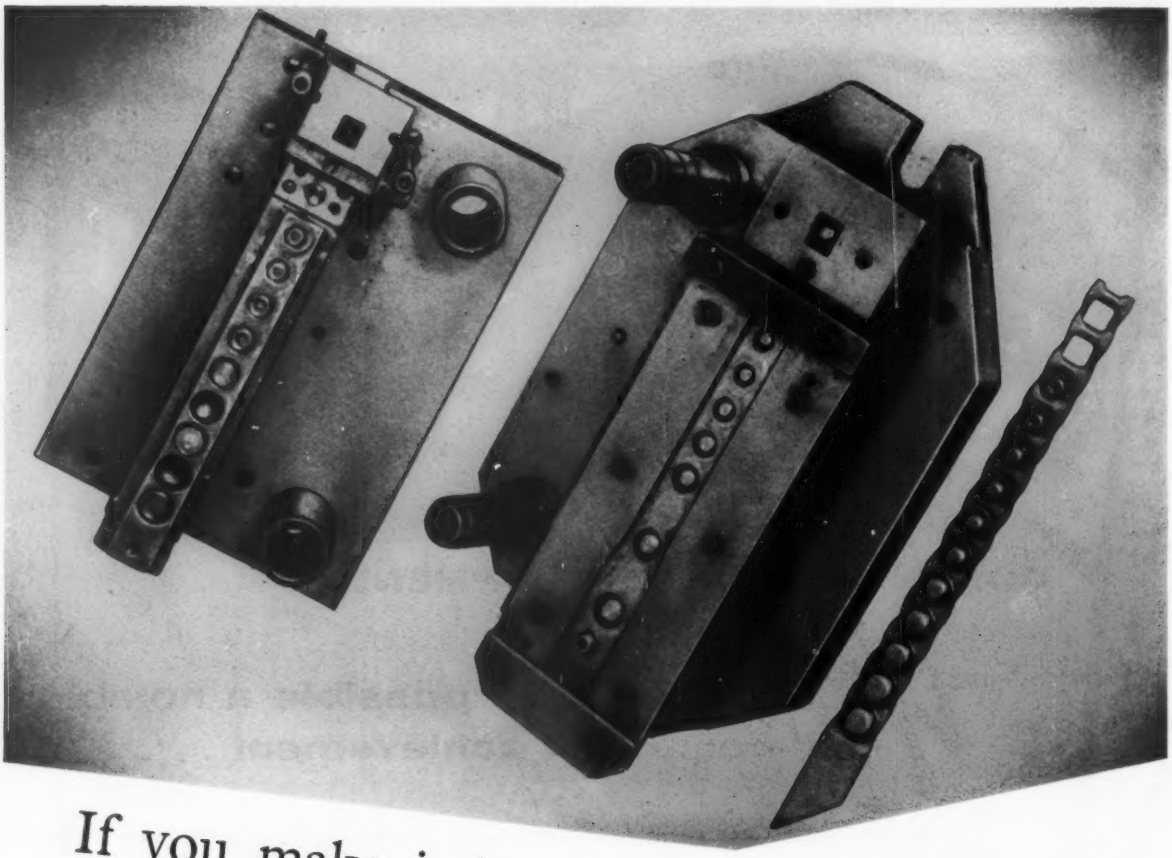

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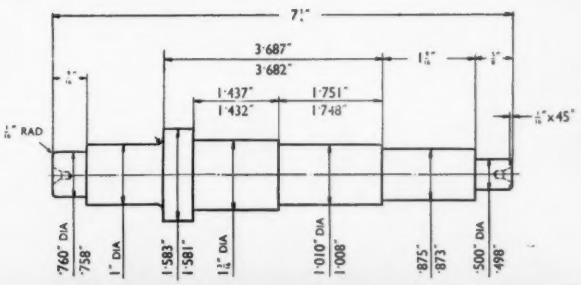

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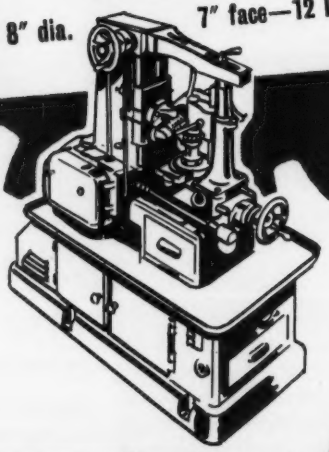

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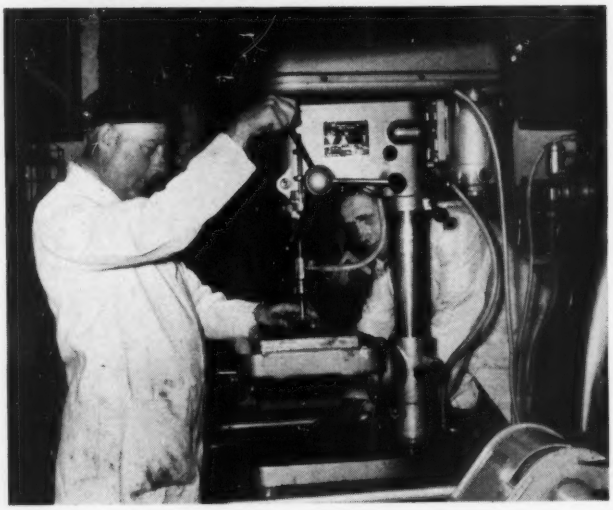

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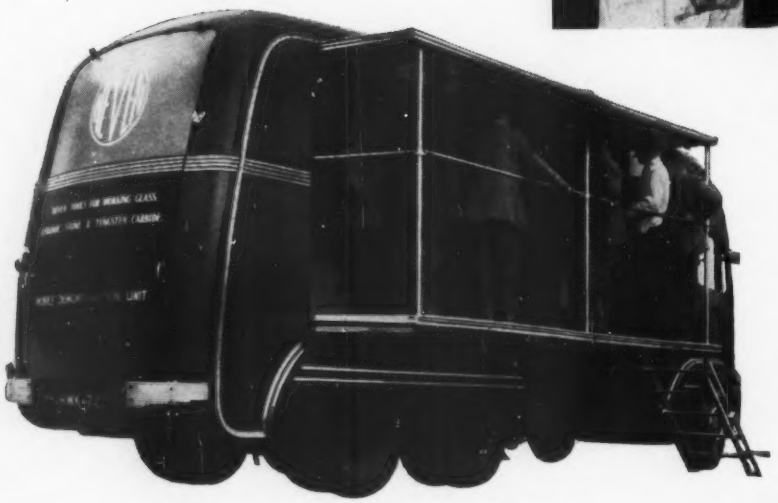

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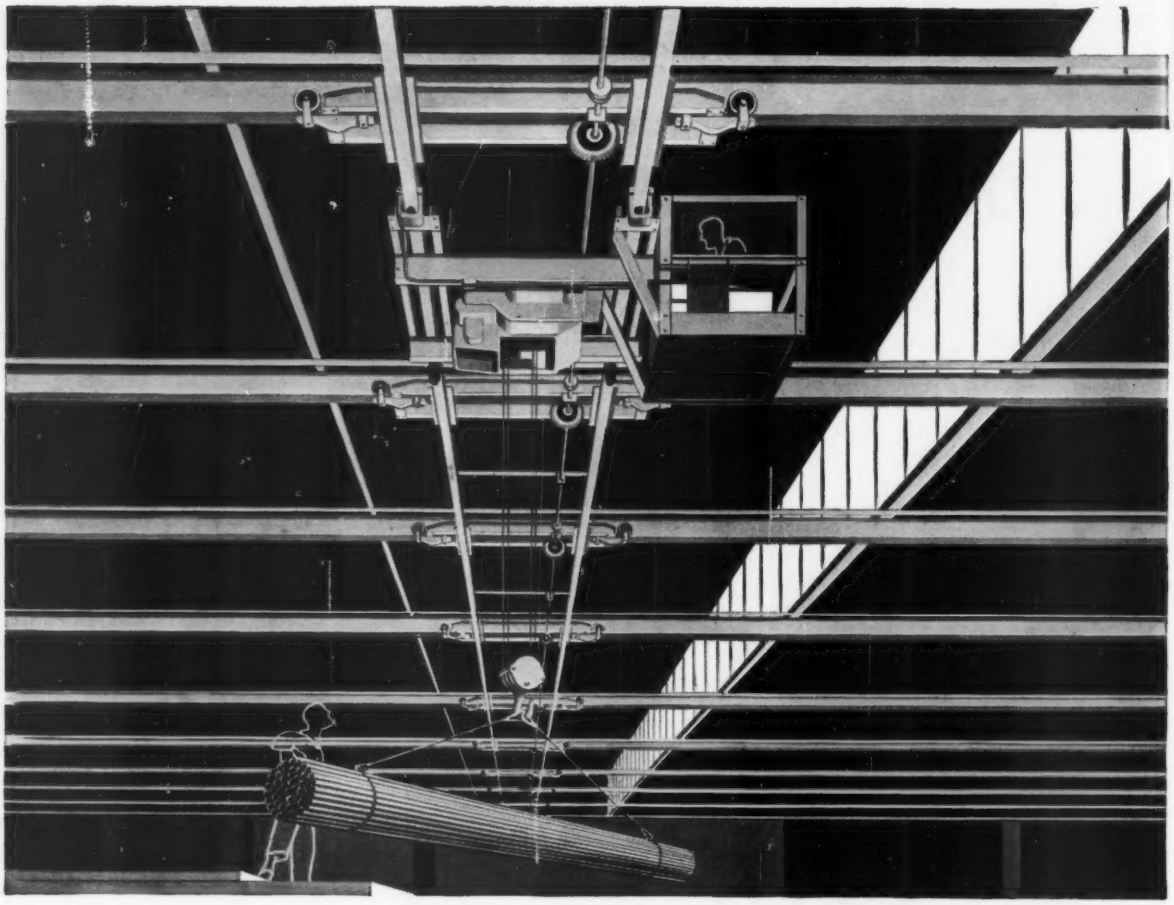

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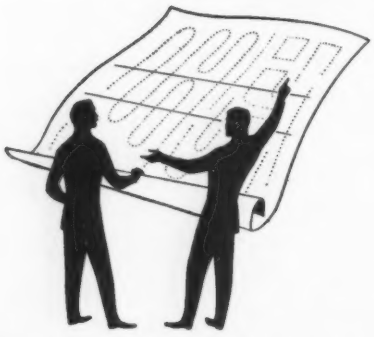

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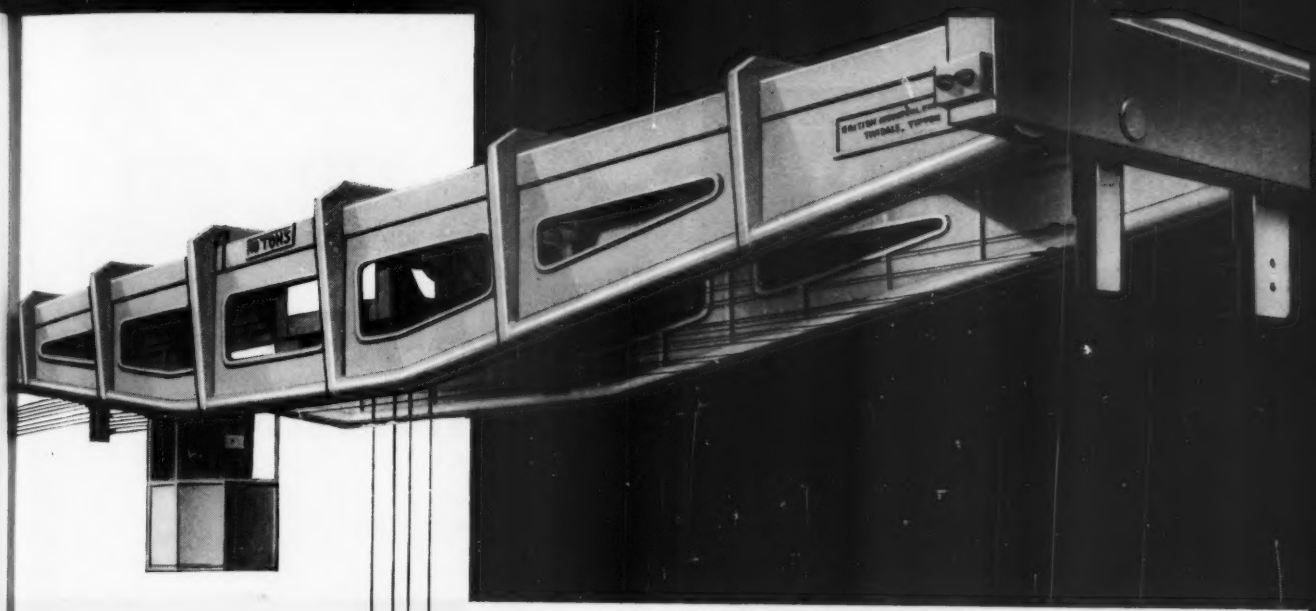

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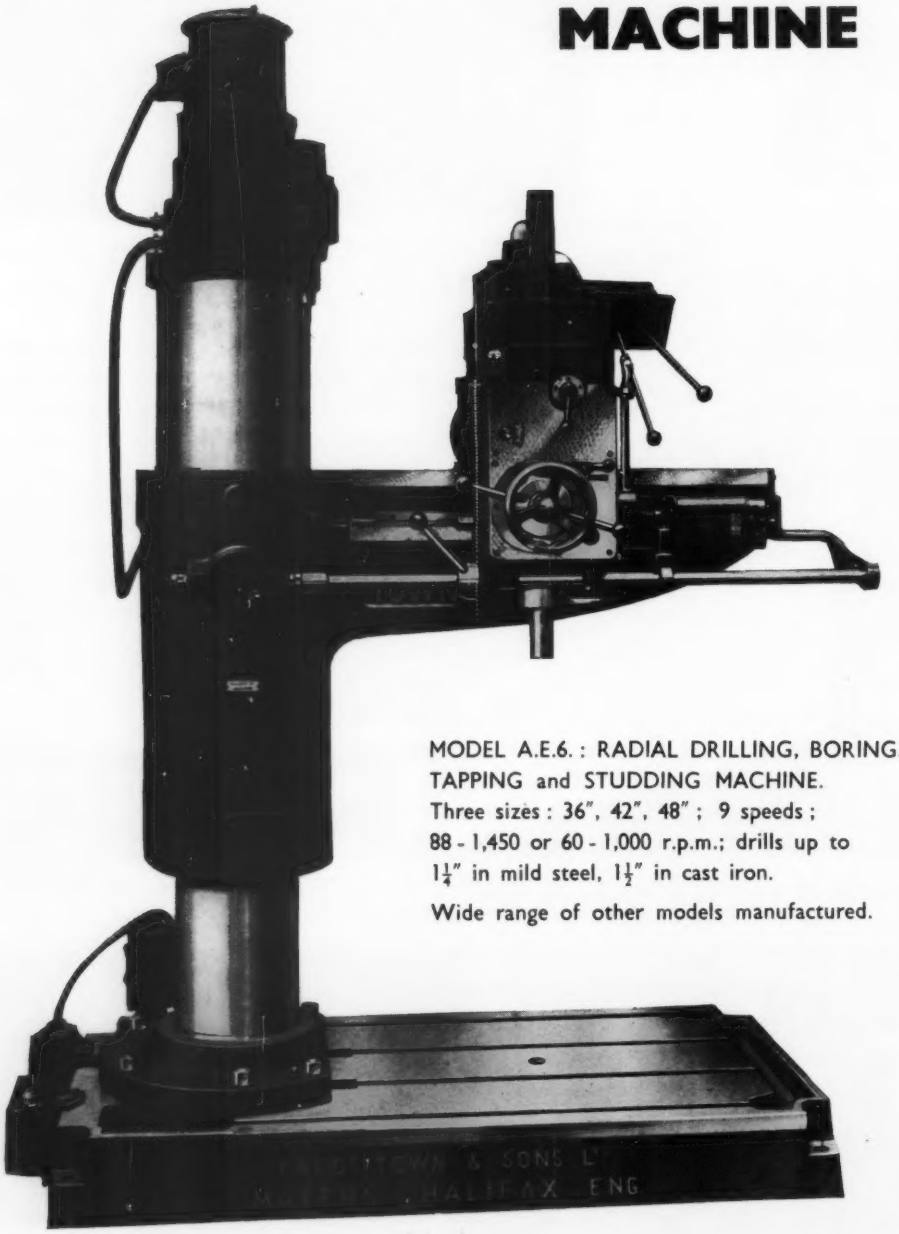

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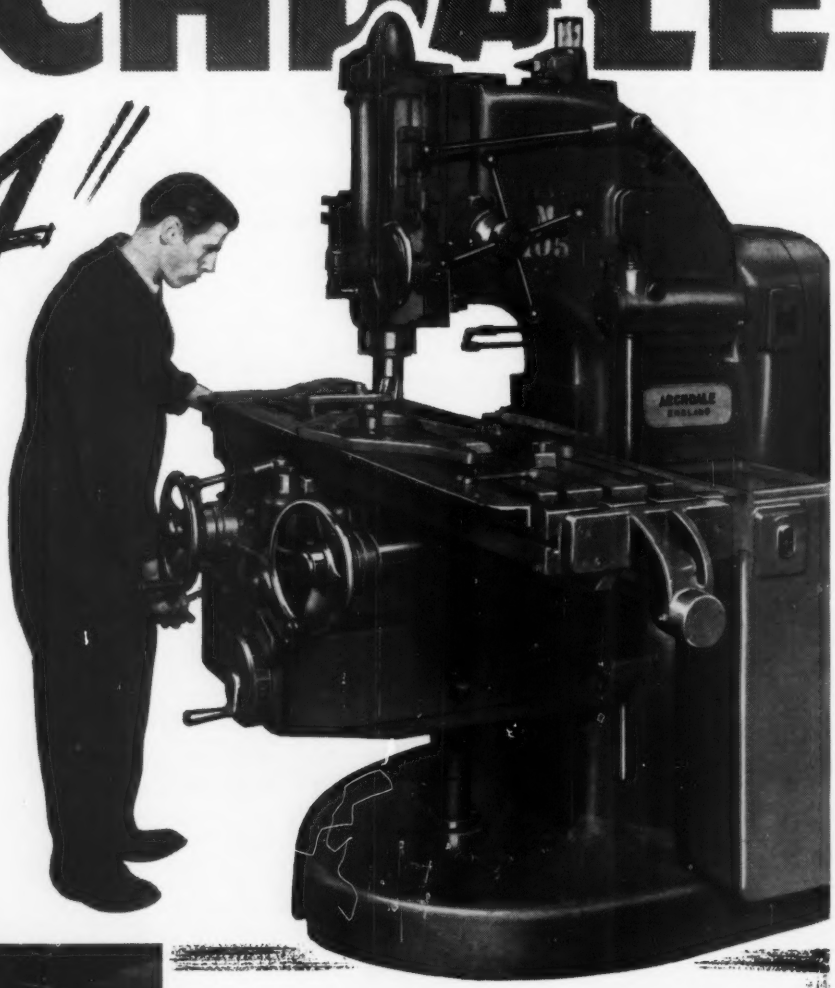

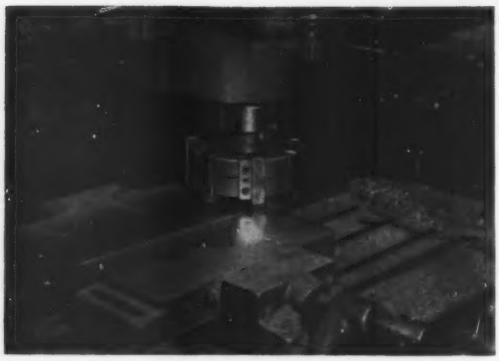

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** The cost of a furnace is not necessarily its purchase price. Even a brief interruption in production may cause severe losses in output and serious inconvenience. The purchaser of a Birlec furnace can be confident that the equipment will not only meet his specification, but will give uninterrupted trouble-free service.*

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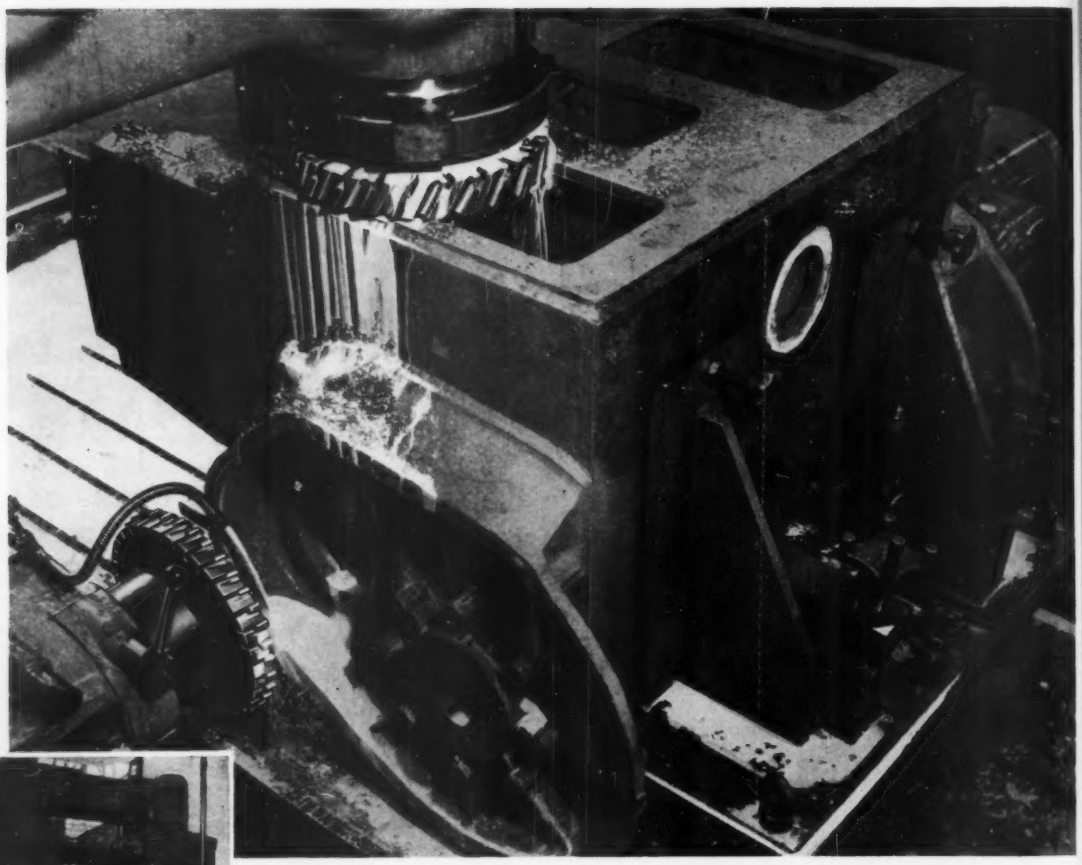
ON THEIR ENGINE PRODUCTION LINES . . .



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Galtona

SERRATED BLADE CUTTERS

for milling the top and side faces on bevel gear case assemblies

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Single or Multi-Head Machines 1, 2, 3, 4 or 6 Spindles

TYPE V20

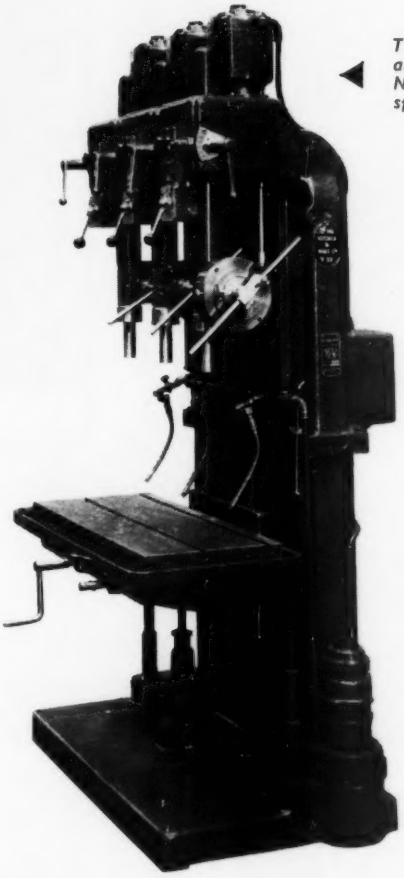
A simple, economic and efficient drilling machine for capacities up to 1 in. diameter in mild steel and when required with reverse to spindle, for tapping up to 5/8 in. diameter in mild steel. A 1 h.p. motor gives 9 spindle speeds through sliding gears. The V20 machine is available with sensitive hand feed only or with 4 rates of power feed and sensitive feed. Automatic trip for depth control is fitted to all machines with power feed.

Reverse to spindle for tapping is offered in two forms:-

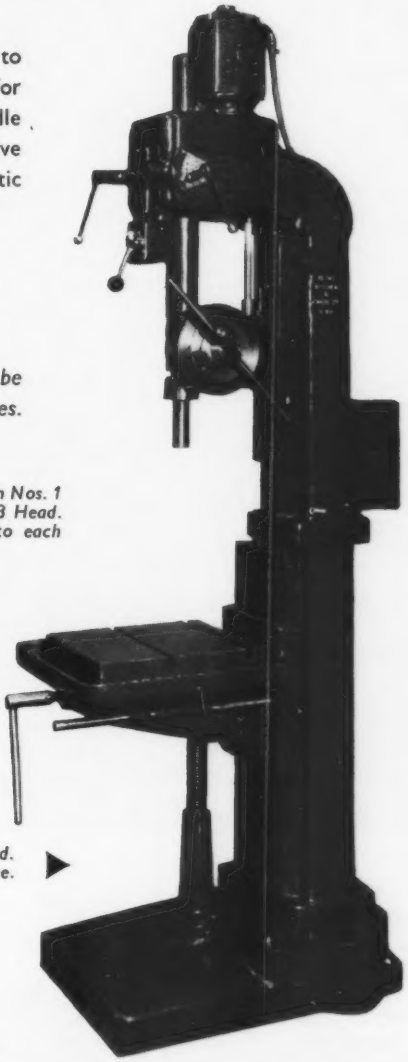
1. Hand-operated electric reversing switch.
2. Automatic by pre-set adjustable trips controlled by spindle travel.

Both table and spindle head have vertical adjustment.

Write for full details of the V20 K & W machine which can also be fitted with various multi-spindle drill heads with fixed or adjustable centres.



Three Head Machine. Hand Feed on Nos. 1 and 2 Heads, power feed on No. 3 Head. Note Coolant Pump and fitting to each spindle.



A single head. Type V20 Drilling Machine.

DIMENSIONS	
SPINDLE CENTRE TO COLUMN FACE (STANDARD MODEL)	8½ in.
SPINDLE CENTRE TO COLUMN FACE (EXPORT MODEL)	12½ in.
LENGTH OF FEED (HAND OR POWER)	6 in.
NUMBER OF SPEEDS	9
TABLE WORKING AREA	15½ × 13 in.
H.P. OF DRIVING MOTOR	1 H.P.

KITCHEN & WADE LTD. *Member of the Asquith Machine Tool Corporation*

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KW375

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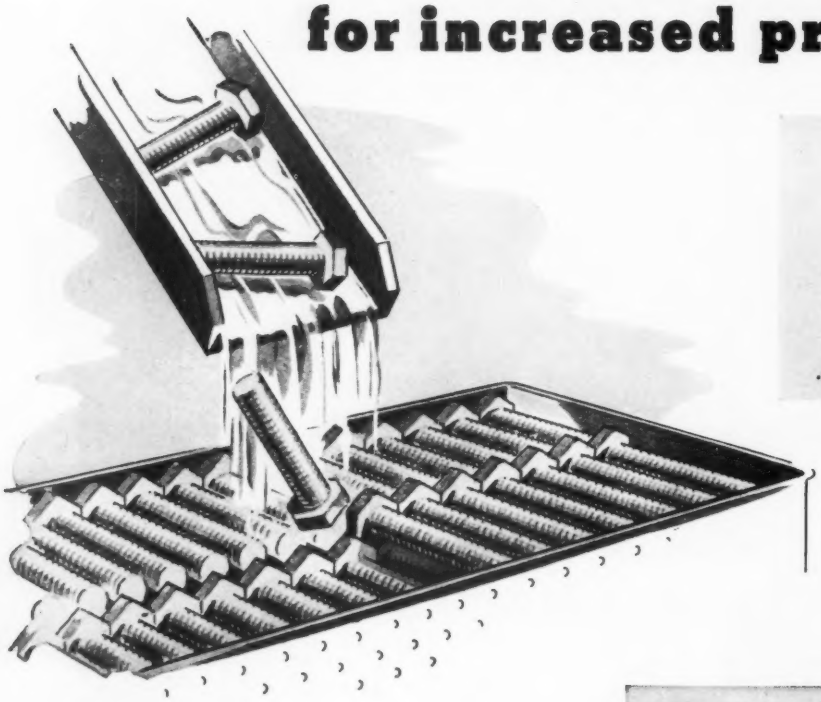
for increased production



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These can be supplied to Admiralty, Air Ministry and many other specifications.

MILLS LEDLOY steels have been known to give an increase in production of up to 100%.

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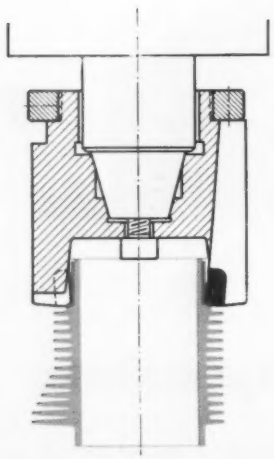
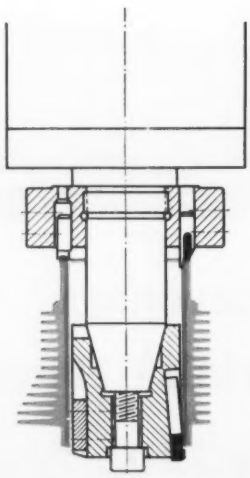


Station 1



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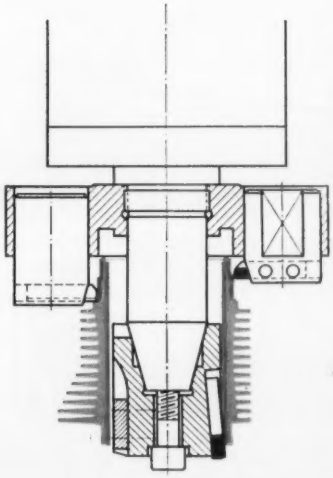
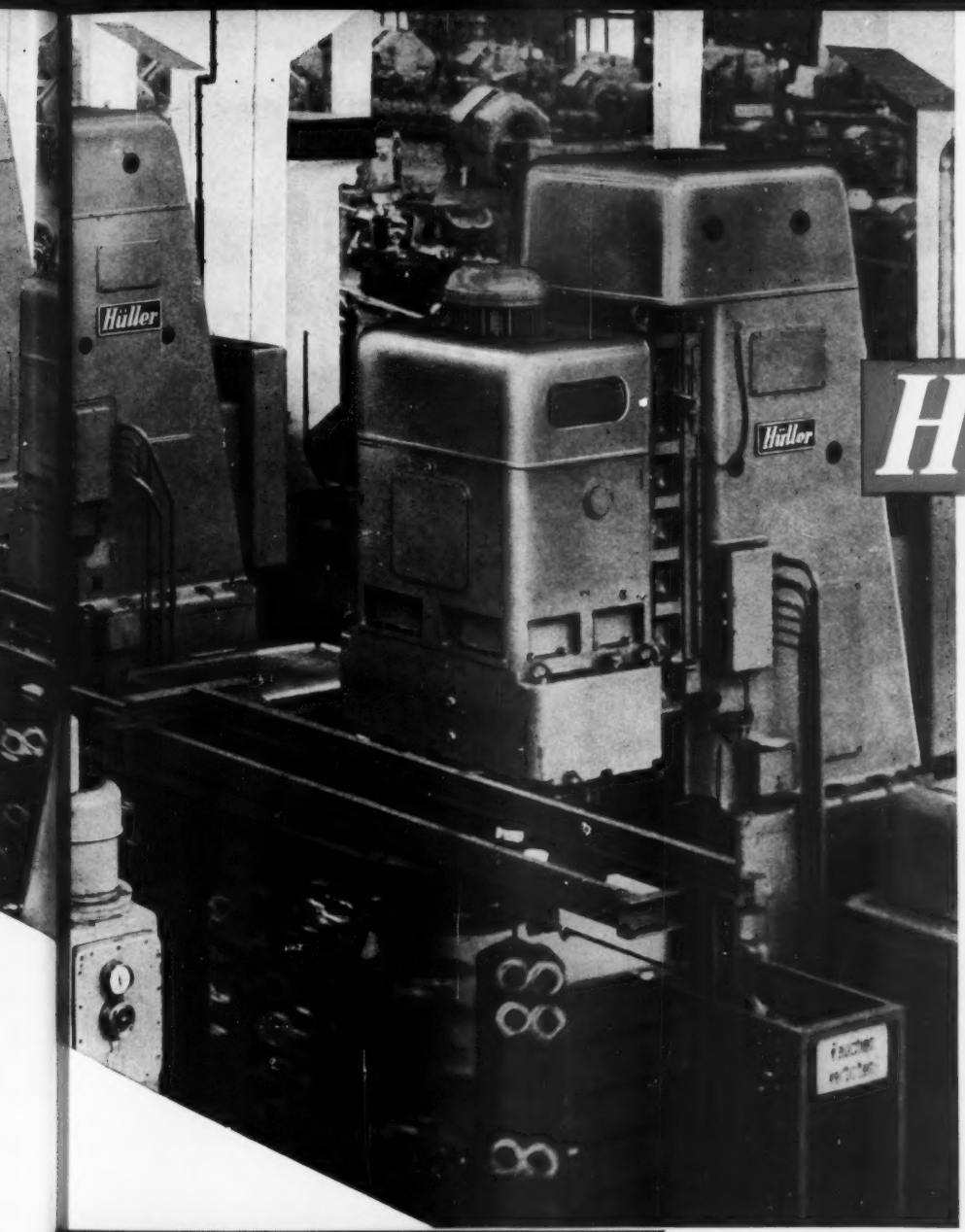


Station 3



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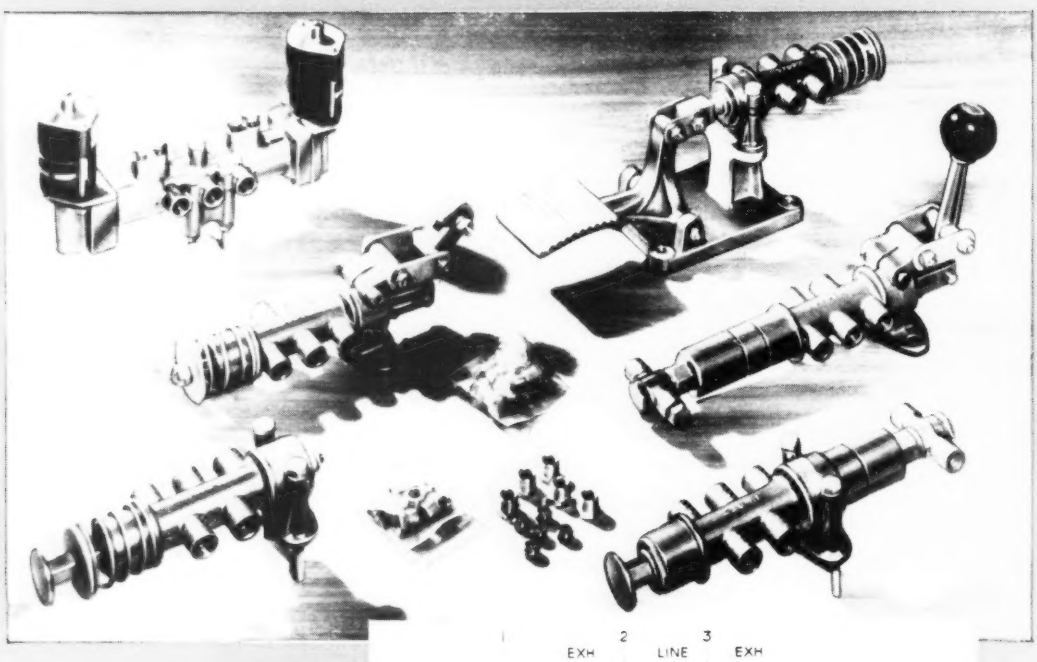

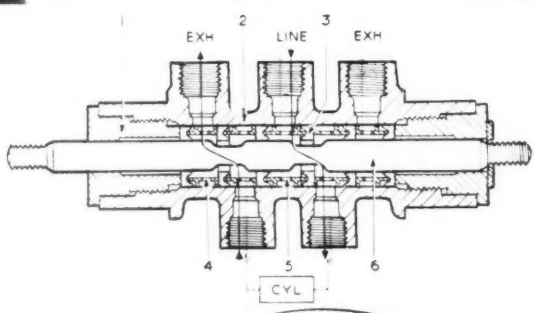

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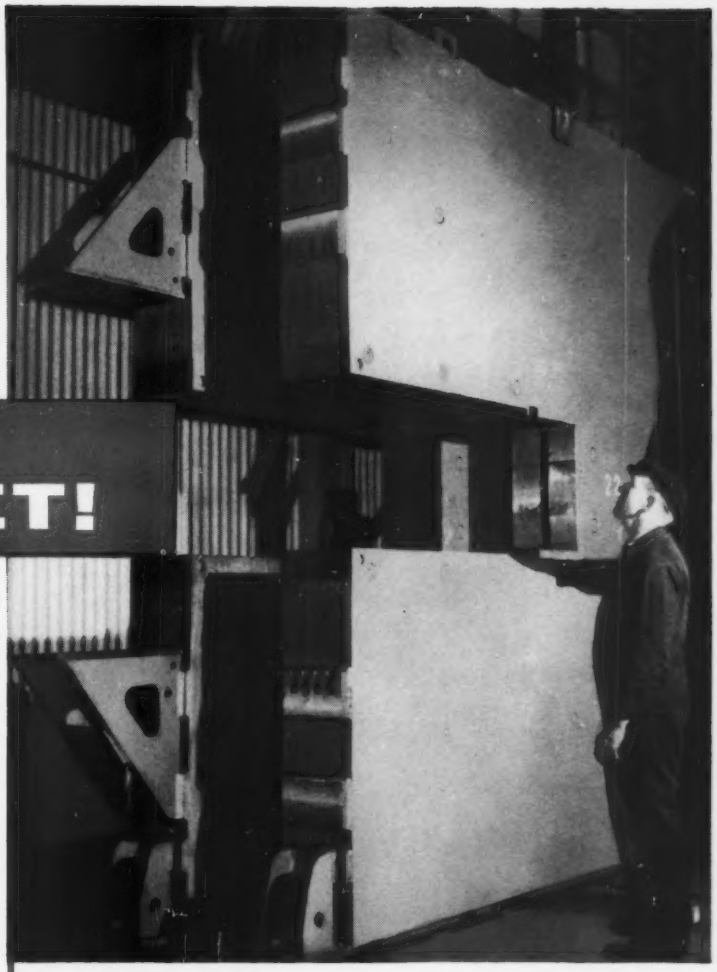
IRST IN THE FIELD—STILL IN THE LEAD



SOME MAGNET!

WHEN 52-year-old Mr. I. Danks was a boy, magnets could easily be hidden in one's pocket. Now a Foreman Erector at Joseph Sankey & Sons Ltd., Manor Works, Ettingshall, Wolverhampton, he is admiring some 20 ton magnet sectors —two of 336 that go into a 7,000 ton magnet core—the biggest in the British Commonwealth and heaviest in Europe outside the U.S.S.R. The magnet core, accurate to one-two-hundredth of one inch and to one-half of one degree, which is for Britain's most powerful 'atom smasher'—the 7 GeV proton synchrotron at the National Institute for Research in Nuclear Science, Harwell, is weld assembled with the aid of Lincoln Electric Co. Ltd. MULTIWELD O.V. and NUWELD 1 $\frac{5}{32}$" electrodes, which are used exclusively for the welding of the side plates to the magnet sector and for the welding of the coil bracket assemblies respectively.

NUWELD 1

A NEW fast low hydrogen iron powder type electrode recently introduced from Welwyn Garden City, is also employed for the welding of the coil brackets to the magnet sector, where full penetration of a double Vee preparation with a 95° included angle is demanded.

For top welding performance to the most exacting requirements leading engineers like Joseph Sankey & Sons Ltd., rely on Lincoln Electric Co. Ltd. electrodes.

We shall be glad to show **you** the benefits that MULTIWELD O.V., NUWELD 1, and other electrodes like them can bring in **your** welding shop.

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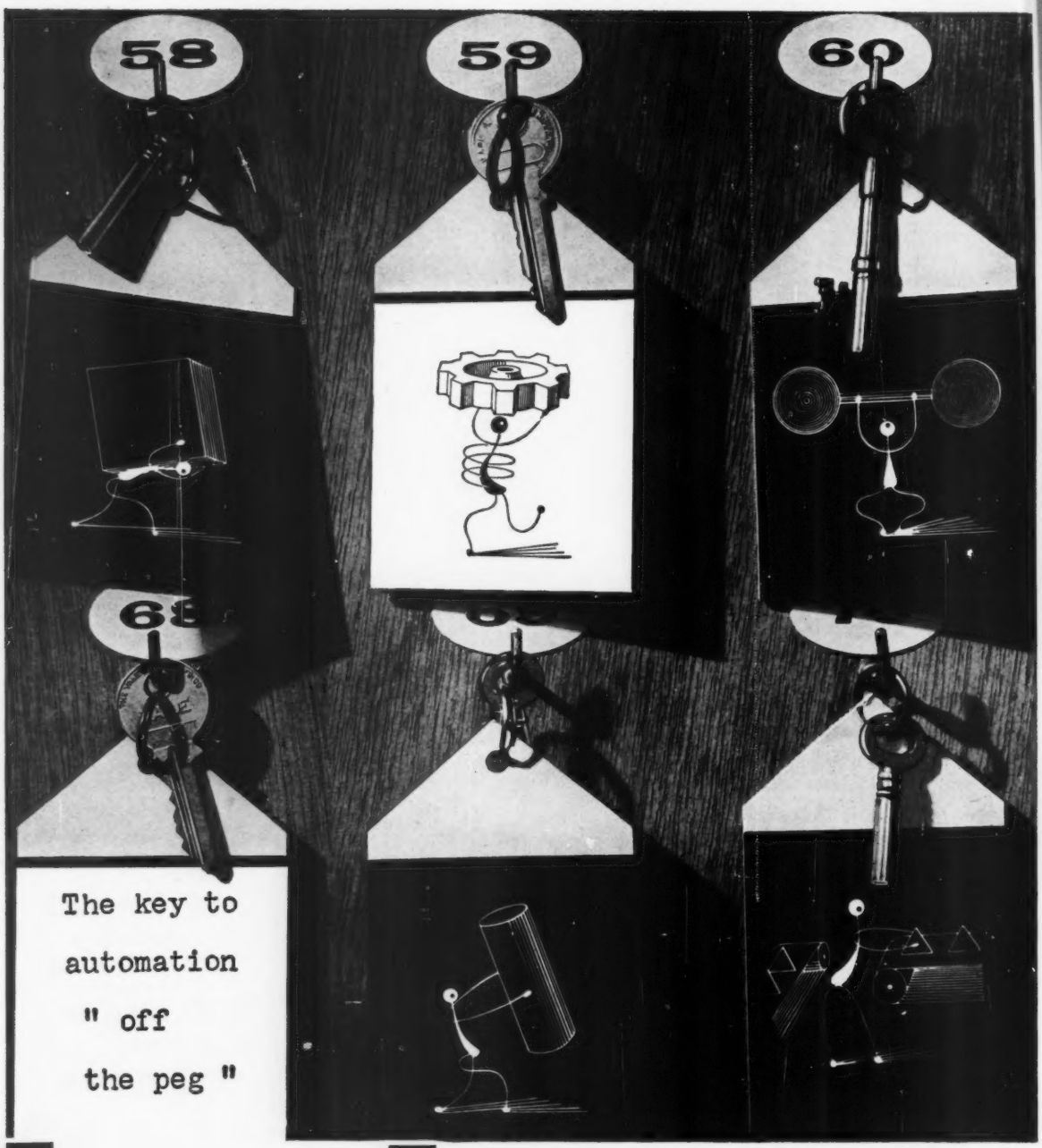

Hymatic Automation

'Progressive' or 'linked line' or 'off the peg' automation means basically the same—Hymatic Automation. As far back as 1953 Hymatic were turning out automatic linking devices, units with which you can link standard or near standard machine tools in your production line. The key is automatic linking equipment: and Hymatic are the people to cut the key. You can learn how automation 'off the peg' can be applied to your production line in a booklet called 'Hymatic Automation'. It describes automatic linking devices and other automatic work handling equipment. Send for a copy to the Hymatic Engineering Co, Ltd, Redditch, Worcestershire.

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OVERHEAD CRANES FOR INDUSTRY

2 FULLY ROTATING JIB UNDERSLUNG CRANE

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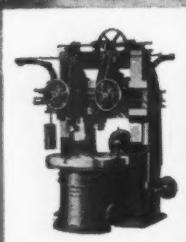
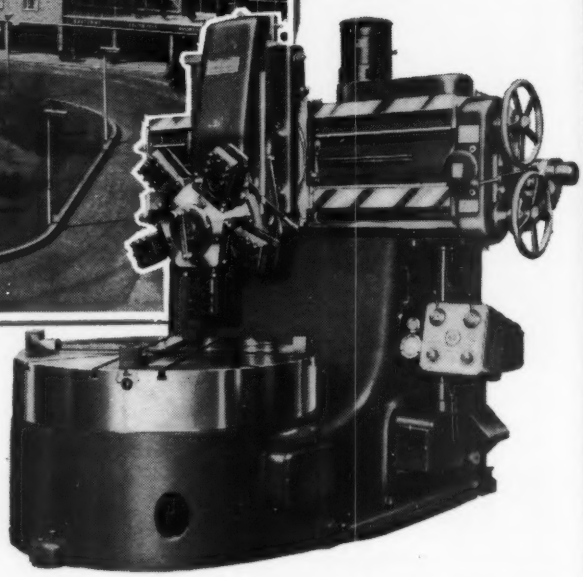


Coventry's Broadgate and a W & B boring mill of the period.

The Changing Years

Over seventy years ago Webster and Bennett began building machine tools and a reputation for quality and value. They have never been surpassed.

Broadgate today, and the latest W & B design.

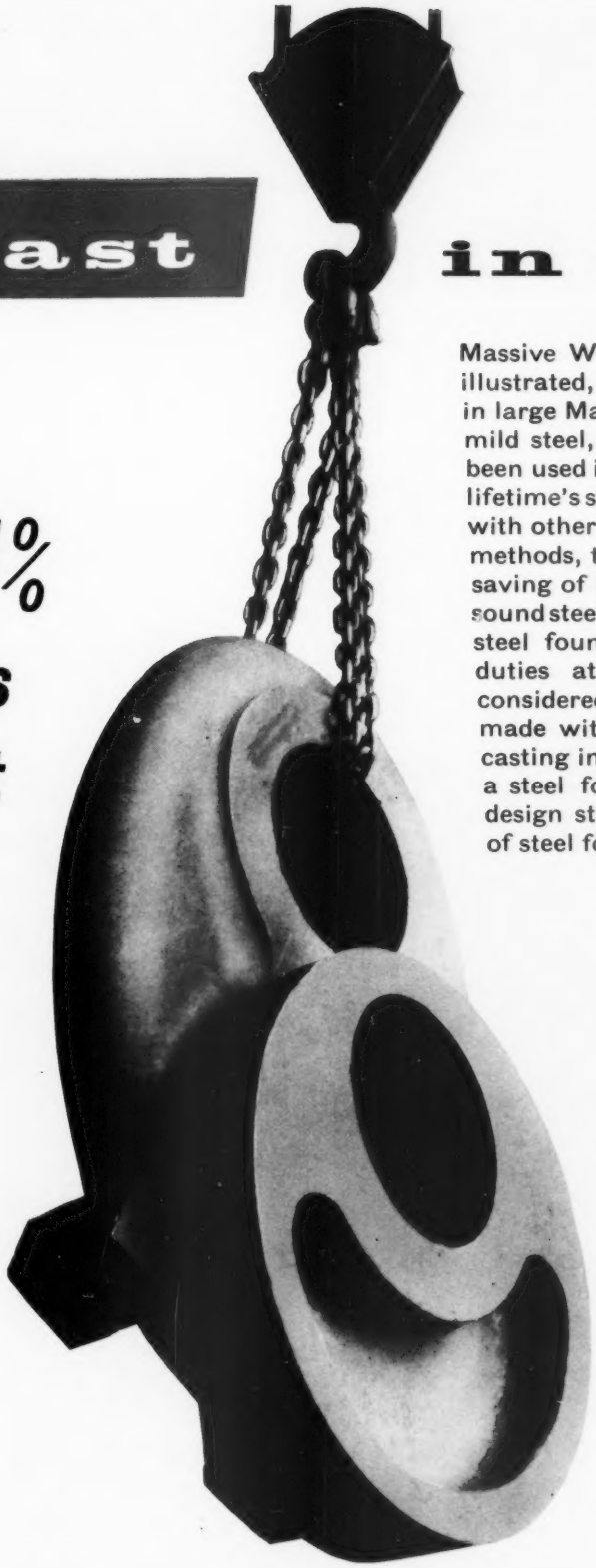


Today. Webster and Bennett boring and turning mills incorporating the most advanced engineering technology continue to enrich their reputation and the future of the people who use them.

WEBSTER & BENNETT LTD., COVENTRY, ENGLAND

cast in steel

at 13% less cost



Massive Webs, such as the one illustrated, are cast in steel for use in large Marine Engines. Made in mild steel, similar castings have been used in crankshafts to give a lifetime's service at sea. Compared with other and earlier production methods, they show a direct cost saving of 13% and illustrate how sound steel castings from a modern steel foundry can meet arduous duties at less cost. Have you considered if this economy can be made with your components by casting in steel ?. Why not call in a steel foundry engineer at the design stage and take advantage of steel foundry know-how.

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THE BRITISH STEEL FOUNDERS ASSOCIATION

Broomgrove Lodge, Broomgrove Rd., Sheffield

A quiet revolution is taking place in the use of materials in Industry.

As the value of first class functional design gains ever increasing appreciation, so the scope of the Industrial Designer becomes wider and his search for new materials more intense.

This is why more and more designers have in recent years turned to Hawley Moulded Fibre with its distinct advantages over most conventional materials in resilience, versatility and strength/weight ratio.

Now an even better material is available to Industry on a production basis. The new Hawley Aqueous Mix Polyester Glass Fibre mouldings, protected by patents in Great Britain and many other countries, offers unlimited scope. Thinner, lighter, yet stronger than ever before and available in a wide variety of attractive finishes, this new and revolutionary material must surely be of interest to all concerned with Product design.

May we send you further information?

The SHAPE of things

These Antler suitcases, handsomely covered with PVC and fitted with a stainless steel section on the edges are a good example of functional design. A pair of plain shells with a glass fibre content weighs approximately 3½ lbs and they have a tensile strength of 7500 lbs/sq. in. and a flexural strength of 9500 lbs/sq. in.

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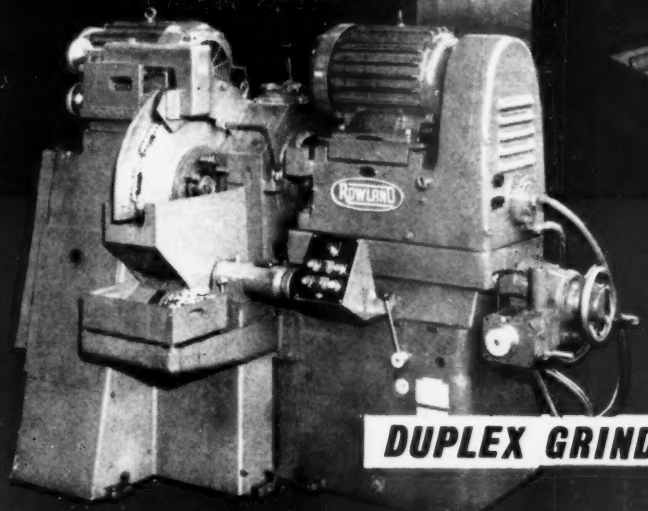

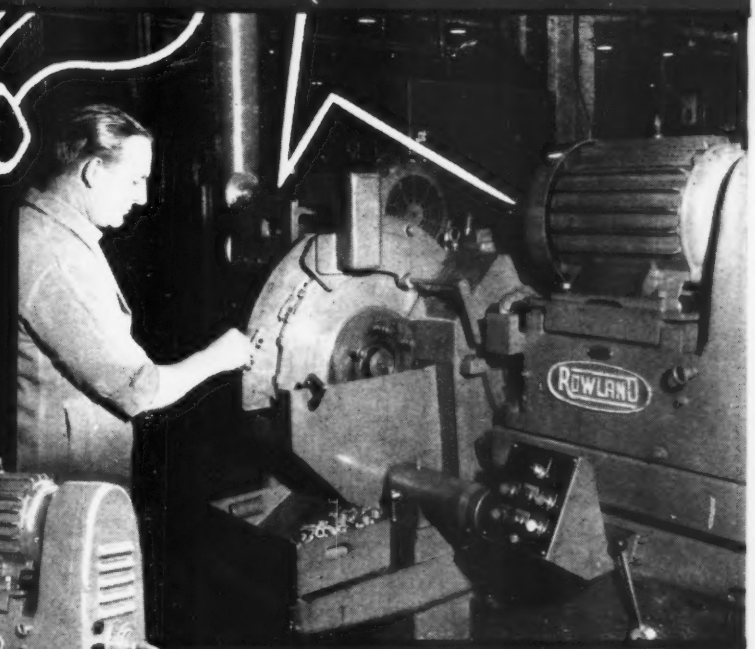

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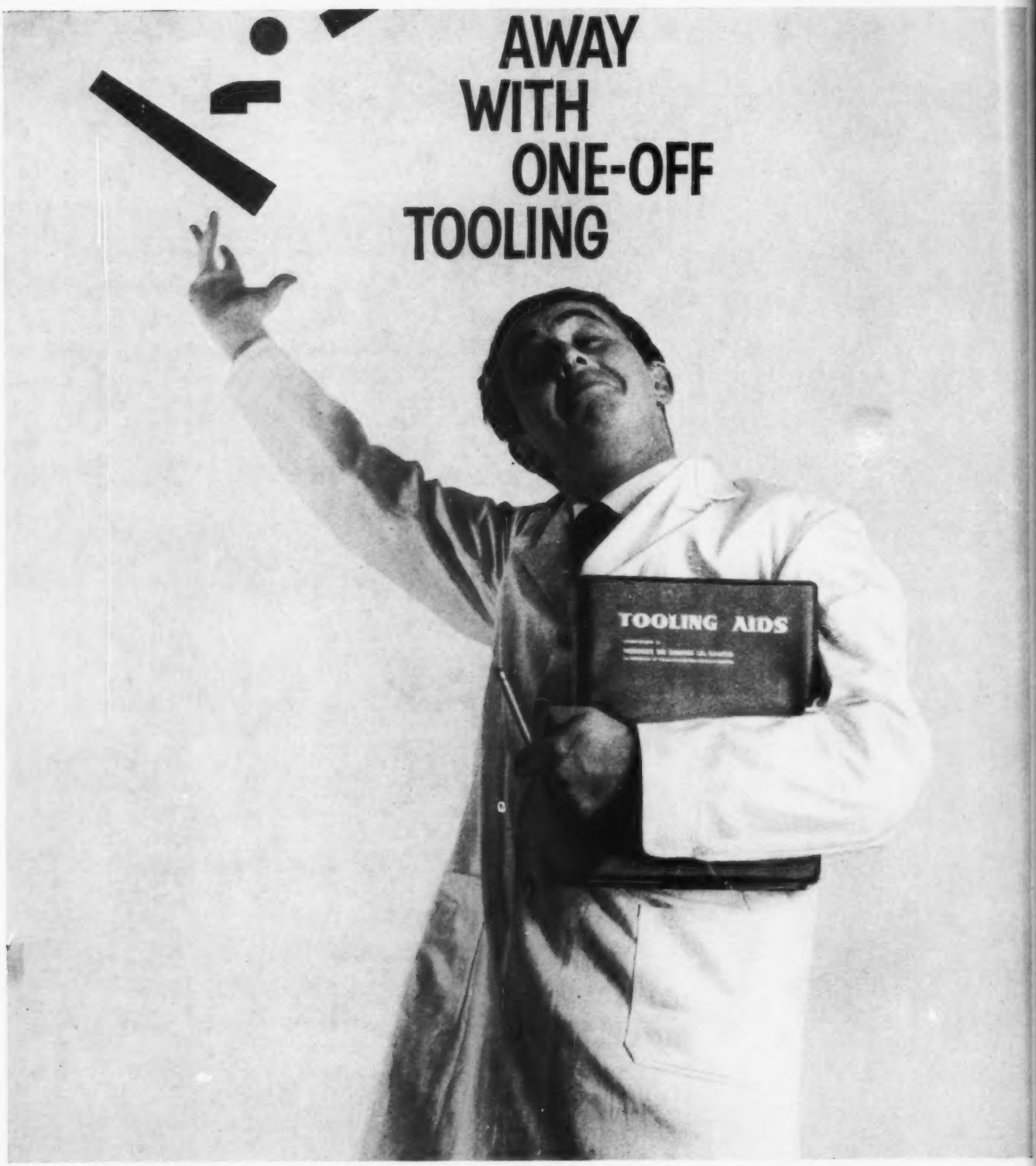
AWAY WITH ONE-OFF TOOLING



You've got trouble. You need one particular tooling item and you need it fast. You've contacted several suppliers but it's a special 'one-off' job and it's going to take them time. Your own tool department can't drop what they're doing, and even if they could, well you know how costly 'one-off' tooling can be.
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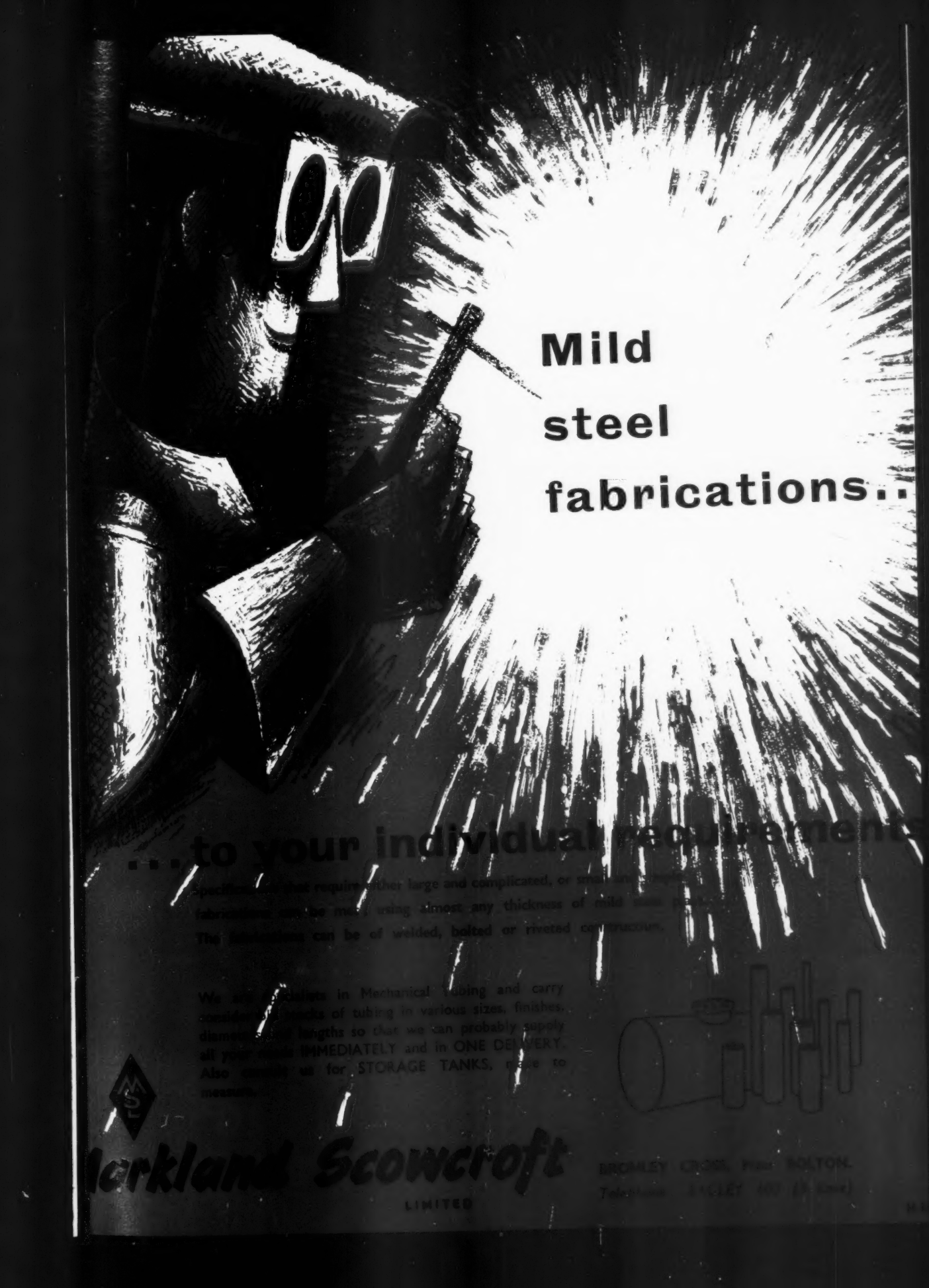
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steel
fabrications..
...to your individual requirements
Specifications that require either large and complicated, or small and simple fabrications can be met using almost any thickness of mild steel plate.
The fabrications can be of welded, bolted or riveted construction.
We also stock plates in Mechanical Tubing and carry considerable stocks of tubing in various sizes, finishes, diameters and lengths so that we can probably supply all your needs IMMEDIATELY and in ONE DELIVERY.
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ADVERTISER'S ANNOUNCEMENT

The Vespa Story

"Out of darkness cometh light"

Post-war Italy was bankrupt—physically, politically and economically it was a scene of desolation. Yet it was in this unprepossessing economic environment that Dr. Piaggio in Genoa started an enterprise which has revolutionised post-war personal travel throughout the world. Within twelve months of Mussolini's mutilation, he had produced over two thousand of the now world-famous Vespa Motor Scooters. Within ten years he was to make a million. Now, the Italian Vespa Company employs more than 4,000 workpeople and the robust little Vespa has completely democratised personal transport. Workmen in factories, doctors on their rounds, bankers, stockbrokers and film stars in every country are all proud Vespa owners. In fact, the Vespa has eradicated motor car snobbery and made tens of thousands of womenfolk motorists for the first time.

At home, pre-war, the name of Douglas was famous in the motor cycle world, but in the immediate post-war years this famous Douglas Company at Bristol had fallen on evil times. It was in the hands of the receiver when Claude McCormack, a Coventry Motor Engineer, took over what seemed an insuperable task of rehabilitation. By chance, whilst holidaying in Italy, he saw the Vespa, and although in charge of a bankrupt firm he nevertheless persuaded the then well-established Italian Vespa Company to grant manufacturing rights to Douglas. The Vespa brought success to the bankrupt Douglas organisation; the jobs of more than a thousand people were saved; bank overdrafts were repaid; shareholders realised unhoped-for prices for shares worth previously only a few coppers, and the Douglas Company became worthy of purchase by the powerful Westinghouse Brake and Signal Company Ltd. Thus the birth of the British Vespa took place also in an environment of economic desolation. Now the Douglas Company at Bristol employs nearly 2,000 people and the output of Douglas Vespas has topped the 100,000 mark. Quite recently the 'Financial Times' reported that the domination of the United Kingdom scooter market by imported European models looks like ending. United Kingdom production has increased 100% in the past twelve months and imports only a quarter, whilst British exports to the United States, the Commonwealth and Scandinavia are expanding. If any proof is required that trials and tribulations inspire mankind to prodigious effort, surely the Vespa story is a pertinent example.

At Kingswood there is a modern Vespa production line modelled on the motor car industry. Large presses stamp out the framework and overhead conveyors take the chassis and components to the paint and assembly shops.

However, the Vespa's attractive colour coat serves as a protective mantle to the robust and reliable power, transmission and braking systems which lie beneath. The construction of the components for these systems presents many problems for the metallurgist. Most of them depend upon heat treatment, carburising, tempering, etc., which demand very close time/temperature

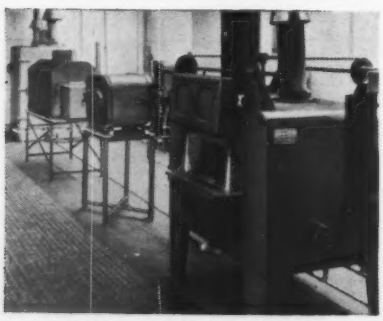

Fig. 2. A view of the new industrial gas showroom opened by the South Western Gas Board.

schedules. For this reason most of the furnaces are on automatic temperature control where thermocouples measure the temperature and transmit an electrical signal to control pyrometers which operate valves in the gas supply according to the measured temperature. This ensures that the temperature never varies from the close limits necessary for correct heat treatment which largely determines the life of the components. The Douglas Company uses town gas supplied by the South Western Gas Board for melting, hardening, tempering and carburising as well as stoving the synthetic paint finishes. For these purposes town gas is the most suitable fuel because its declared calorific value lends it well to precise automatic control. Other advantages are, of course, that there are no interruptions for fuel deliveries, and the gas meter provides the simplest and cheapest form of fluid fuel costing.

In the foundry gas is used for core drying, and aluminium alloy melting is carried out in three gas-fired melting furnaces, the molten metal being used for the gravity die-casting of the light alloy components. Crankshafts, gears, etc. require special heat treatment to fit them for their arduous life, and in the Carburising Shop there are three gas-fired muffle furnaces as well as a high-speed tempering furnace. Other non-ferrous components are treated in gas-fired salt bath furnaces.

The standard of finish on the Douglas Vespa is extremely high. The chassis, mudguards, etc. having been assembled, stress-relieved and filled, pass on conveyors into the finishing shop. After being sprayed with a number of priming and finishing coats of paint the components pass, still on conveyors, into a gas-fired infra-red paint stoving oven which was specially designed to suit the awkward shape of the chassis, thereby ensuring that each part of the painted surface received adequate heat. Again town gas was chosen as the fuel because it lends itself more easily to the close time/temperature schedules required to cure the modern synthetic paints.

Undoubtedly the large output of Vespa Scooters has benefited from the close co-operation between the South Western Gas Board, the equipment suppliers and the Douglas Company. As part of its service to industrialists in the South West the South Western Gas Board has recently opened an Industrial Gas Showroom where factory executives can inspect working examples of infra-red tunnels, natural draught oven furnaces, muffle furnaces, recirculating ovens, etc. Anyone can bring along the components in which they are interested and try them out with the equipment in advance of purchase. A small pottery kiln is in great demand by schools in the district, and examples of decorated and glazed pottery reflect high credit not only upon the schoolboys and girls but upon the precise time/temperature schedules obtainable with town gas in a relatively inexpensive kiln. In addition, there is a wide range of gas burners together with ancillary equipment such as flame protection and ignition systems where automatic temperature control figures prominently.

This Industrial Gas Showroom is one positive example whereby the Gas Industry through its Industrial Gas Officers at the Area Gas Boards is serving industry—these officers from all over the United Kingdom meet regularly to discuss developments, so that any manufacturer approaching any Area Gas Board has at his disposal the pooled knowledge throughout the country in some 4,000 different trades and industries served by gas. One practical result of this service is reflected in the Douglas plant at Kingswood, Bristol —and the name of Douglas is in turn reflected in the ever-increasing market for its ever popular and glamorous Vespa Scooter.

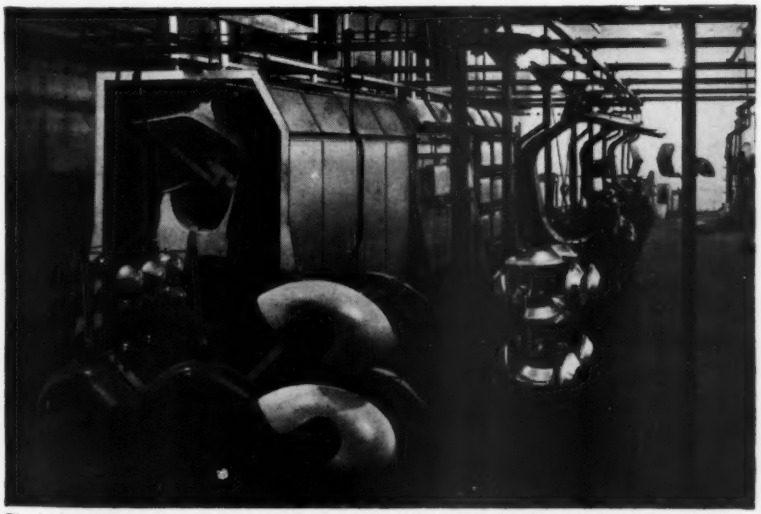

Fig. 3. Gas-fired paint stoving oven for Vespa parts including chassis, lamp housings, steering columns with mudguards, engine wings and fan cowlings, installed at Douglas Engineering (Kingswood) Ltd.

Fig. 4. A view of the gas-heated core drying installation in the foundry of Douglas Engineering (Kingswood) Ltd.

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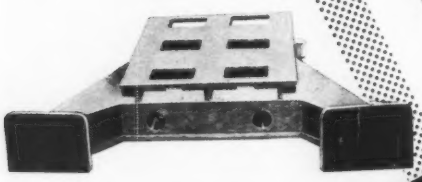

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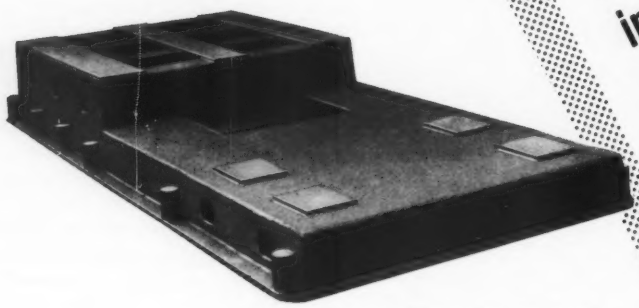

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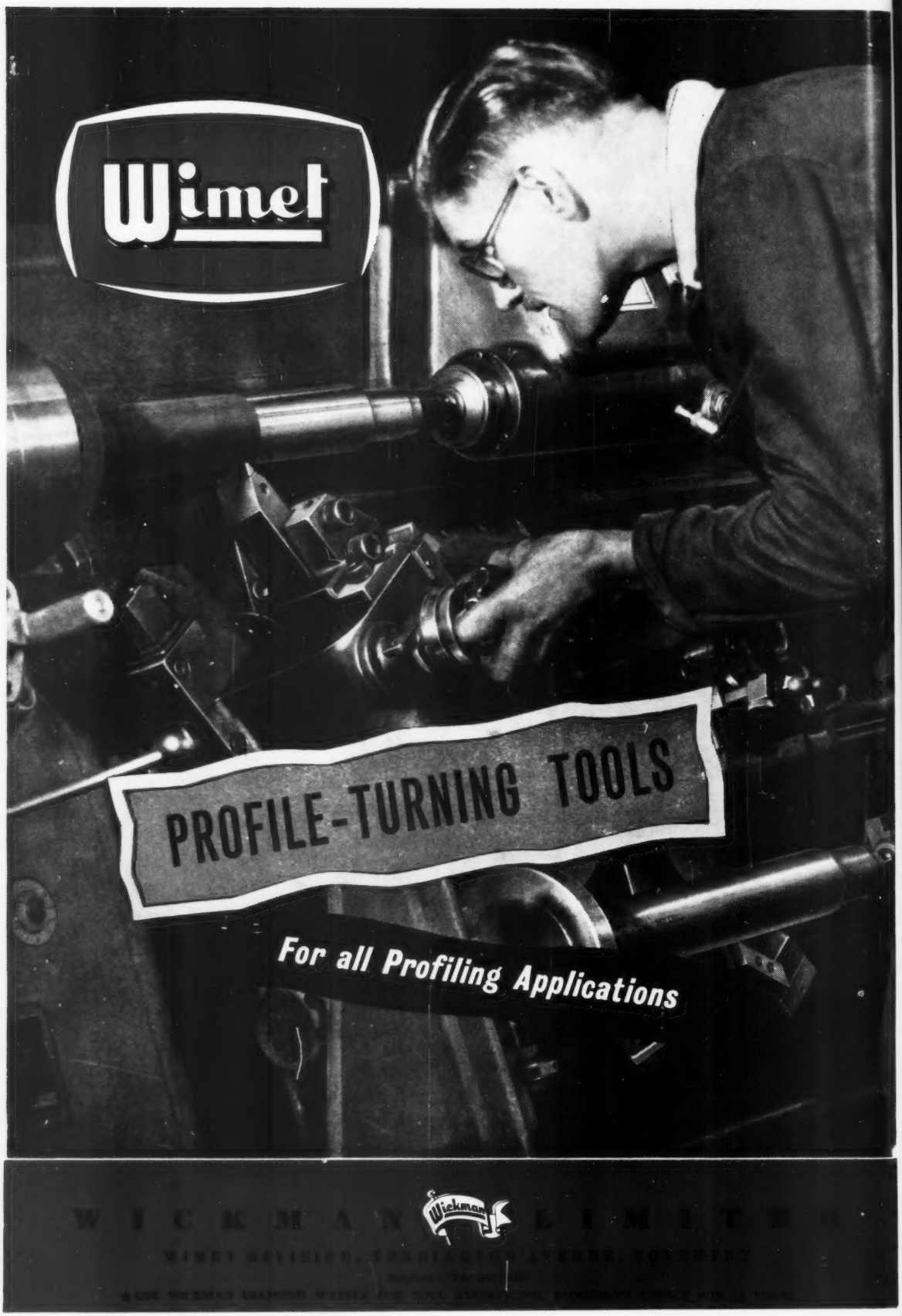

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The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 No. 1 JANUARY, 1960

IT is now several years since the size and style of the Institution's Journal was changed. This change in appearance, however, was the outward sign of a continuous endeavour by the Editorial Committee and Editorial staff at that time to provide a Journal which would reflect the growing prestige and range of interests of our Institution.

The changes which you will have noticed in this issue of the Journal are again the immediate outward sign of this continuing endeavour and of much careful consideration and discussion not only on the part of your Editorial Committee, but also of your Region and Section Committees.

As the Chairman of Council has said in his Report, which is printed in this Journal, there is some virtue in change for its own sake, but your Committee earnestly hope that the improvements in layout and presentation, the increased coverage of Section and Region news, and the introduction of additional features such as progress reports on work being carried out within Universities and Colleges of Technology engaged on production engineering research, will help individual members to keep in touch with the ever-growing impact of production engineering activities and will help strengthen the bond between the Institution and individual members in which the Journal plays such an important part.

This process of continual improvement is in no way complete, and future Editorial Committees will continue to be concerned with ways in which the Journal can be improved and can be made to serve not only the Institution as a corporate body, but also the interests of its many members wherever they may be. The Committee, in their recent deliberations, have been very much helped and encouraged by the ready way in which many members have come forward with suggestions for improvements and with constructive criticisms. We look forward to a continuation of this close personal interest which is invaluable to us in our work.

B. E. STOKES,
Chairman,
Editorial Committee.

HUMAN RELATIONS IN INDUSTRY

by R. A. BANKS

Director in charge of
Group C (Ammonia and Agriculture)
Imperial Chemical Industries Ltd.

Mr. Banks took an honours degree in Natural Sciences at Cambridge, and then joined Brunner, Mond & Company at Northwich, in 1924. For five years he worked in an alkali factory, ending as Assistant Works Manager.

He spent the next four years in India, surveying the chemical manufacturing possibilities there. On return to Northwich (now I.C.I.) he joined the Techno-Commercial Department and was promoted to the Alkali Division Board in 1938, and to Managing Director in 1944.

In 1952, he was appointed to the I.C.I. Main Board and shortly afterwards became Personnel Director. In 1959, he was made Director in charge of Group C (Ammonia and Agriculture).

This Paper was presented to The Institution of Production Engineers at the University of Bristol on 12th October, 1959.

MR. HANCOCK, in his original Paper in December, 1956, said when considering people in industry, "Who can say what is right and what is wrong? But experience can say that this has been found as a better way than that. Therefore, it is possible, and may be useful, for one to give opinions on such a subject as human behaviour and people, based on experience and practice."

In my own contribution I can do no more than that. I shall not say anything new, but I am fortunate in having many years' experience in a large industrial company which has been particularly concerned with human relations, beginning with the companies from which it sprang, over a much longer period. I shall try to draw some broad conclusions from those experiences.

A Paper on human relations cannot easily avoid the discussion of organisation and administrative arrangements such as wage rates, pension funds and joint consultation, but it is, I believe, of major importance to remember that human relations in industry, or anywhere else, are not a question of mechanics or conditions. They are relations that exist between individuals; between a works manager and his plant managers; between a plant manager and his foremen; between a foreman and his men, as well as between a works manager and a sales manager, etc. There are many cases of good relations and bad conditions and *vice versa*. The relations between men

working long hours on some experimental plant under trying conditions can be, and often are, better than those between people working in air-conditioned offices.

This does not mean that good organisation and industrial machinery are not desirable, especially in a large organisation. But without a right attitude of mind of one man towards another at all levels and in all jobs in the industry, mechanics are of no avail. There are examples in industry of wonderful organisations on paper for the avoidance and settlement of industrial disputes, which just fail to work because of the lack of human understanding and the positive will to make the organisation work.

Though we are proud of what we have achieved in our Company in working together cheerfully and efficiently, we are equally conscious of many defects and shortcomings. Even to maintain our present standards, constant care and watchfulness are needed, as well as new attitudes and approaches as fresh problems arise to try our strength and as changes in the beliefs, education, training and habits of people take place. To improve our standards demands even more of us in imaginative thought and action.

Although I shall outline many of the arrangements that we have developed and found valuable over the years, I shall try to underline the attitude of mind of managers and men that runs through them. I shall try to show how this attitude was bred and fostered and how, now that the pioneers have gone, we try to develop this attitude in the newer employees and the future leaders at all levels.

the benefits of a good historical background

In order to understand my particular experience, it is necessary to mention the history which in my Company we have inherited. Perhaps the greatest asset in good industrial relations is to be fortunate enough to inherit a history of good relations. The weakness of a particular manager, the hot-headedness of a particular shop steward, will not cause serious trouble in a firm where for many years confidence in each other has grown up. Both the manager and the shop steward will be recognised for what they are and allowances will be made.

I have spent much of my working life in mid-Cheshire in the part of the Company that goes back to the 1870's. From the very earliest, the records show the concern that the two pioneers, Dr. Ludwig Mond and Sir John Brunner, showed for all their employees.

In 1884 they recognised that the men should not work such long hours without some break and instituted an annual week's holiday. In 1902 they added an additional week's pay so that their men could go away to the sea for their week's holiday. Working conditions in this country generally did not reach this point for more than another 40 years.

In 1889 we find Sir John Brunner addressing a meeting of employees and urging them with all his power of eloquence to join a trade union. The recognition of trades unions as having a particular and vital part to play in industrial government has continued ever since.

A staff grade scheme was introduced in 1928 which gave increased security to 25% of the hourly paid employees with five or more years' service. Their notice was increased to a month and they received their full weekly wage when sick and unable to work. In later years the percentage of those eligible who enjoy these benefits has steadily increased, and is now over 80.

Works Councils, pension funds and awards for long service were all started more than 30 years ago in some part or other of the Company.

On the management structure side there were two features of note. It was recognised from the earliest years that the man in charge of the plant should be in charge of the men. He might have advisers on engineering or labour relations or special technical problems, but he, the manager, was responsible for decisions covering both the plant and the men he was leading.

The other feature was the recognition of the importance of the foreman. To the hourly-paid employee he was the first line of management and leadership. He must then be a man of considerable moral fibre and must receive proper recognition. Care has been taken for many years in the selection and training of such men and they have been members of the staff for over 25 years.

In addition, the importance of the attitude of employees of all ranks to each other has been stressed throughout our history. This has been emphasised over and again not only in the written and spoken word, but by the actions of men at all levels, and especially of those at the top of the Company.

Since the start of the Works Council Scheme, the Chairman and Directors of the Company have turned out for a full day twice a year to meet the elected representatives and take part in the discussion. On each occasion, when in the country, the Chairman has presided. By such action it has been made clear to all present, including the considerable number of managers, that at the highest level great importance is attached to personal relationships, and an example has been set in the treatment of all employees with dignity and respect.

In 1928, soon after the formation of the Company, Mr. H. J. Mitchell, a Director of the Company, summed up the importance of people's attitude to each other by saying :-

> "The Company's view is that the policy best calculated to promote efficiency is to encourage in each employee a sense of partnership . . . . Again, while preserving the unity and well-being of the personnel as a whole, there must be, and is, constant endeavour to give each employee due consideration as an individual and every opportunity for self-expression . . . . This involves the education of all who occupy managerial positions. It aims to show that the existence of good relations between both parties is primarily a matter of mental attitude on the part both of management and of employees, and while it is realised that the cultivation of

this outlook adds still further to the responsibilities of the management, it is insisted upon as a definite duty of all our officials."

the present and future and some problems

I should like to outline a few of our present practices and the problems that are associated with them, and to show how their solution is dependent on the mental attitude of employees to each other.

wages and negotiations

We negotiate as a Company separately with the General Worker and Craft Unions a basic wage rate for each group. Although on some occasions agreement is harder to reach than on others, only once in recent years was it necessary to resort to arbitration and never has there been a strike or lock-out on such issues. The negotiations, at which many are, after all, old friends, take place in a friendly atmosphere and tempers are seldom, if ever, roused. Arguments are freely and frankly exchanged, and over the years an attitude of trust has been built up so that bluffing and exaggerated claims and excuses have been reduced to a minimum. A sense of fun and humour is seldom far below the surface and has often been called upon to relieve a tense situation.

Agreements on conditions of employment, other than basic wages, are negotiated with a joint body representing all unions. The interpretation of these agreements is carried out at local level between Works Managers and the local union officials, and although the machinery in each case is identical, we get the odd manager who fails in his approach and may, for instance, rely on emphasising the "prerogative of management". Though the negotiating machinery is the same throughout, the results are very different.

Over and above basic rates of pay, we have a system of appraising jobs under four headings and this results in increased rates of pay according to the character of each job. The general system of appraisement and of reward for the various characteristics is the subject of overall agreement with the trades unions. The appraisement of each job is carried out by three or four managers who thereby are party to the wages that are paid to the men. The shop steward is asked to be present when the job is appraised in order to be certain that all features are taken into account, and the result can be challenged through the ordinary procedure. The introduction of job appraisement has strikingly reduced the numbers of claims and disputes about wage rates and moreover, when they do occur, it provides a basis for reasoned discussion.

We have found in practice that this has worked surprisingly smoothly. Few appraisements are challenged and, where they are, if re-assessments confirm the original results, these have been accepted. The wages that result for each man are not the result of theoretical calculation by a remote expert, but of well-informed opinion at various levels of management well-known to the man himself and challengeable by him.

We are at present concerned with the problem of how to fix the appropriate reward for certain workers to whom it is not practicable to pay an incentive bonus based on the measured output of work, such as we now pay to a large proportion of payroll employees. This is a most intractable problem and the trades unions and ourselves are grappling with it, together and separately. There is no right and easy answer, but by these studies and discussions we believe a fair and reasonable solution will be found.

Right from its start, the Company has taken great pains to ensure that directors and managers at all levels have opportunities and encouragement for getting to know the appropriate trade union officials. Before Christmas every year the directors give a luncheon to trade union officials from headquarters and from the Company's main operating centres throughout the country. Managers from the various factories and divisions are also there, and this function sets the pattern for many local social occasions throughout the year when managers and union officials meet informally. Great pains are also taken to keep the trades unions informed at the earliest possible moment of changes which are likely to affect their members. When this cannot be done officially at first, it is often possible to arrange unofficial and informal meetings because our people know their opposite numbers sufficiently well. Once again, it is the personal relationship between an individual manager and a trade union official which makes the machine work smoothly.

promotion policies

One of the main factors in promoting efficiency and in attaining good human relations is good selection and development of chargehands and foremen. On the other hand, if it is not well done, it can lead to much bitterness and to accusations of the "blue-eyed boy" variety. A widely-known scheme for promotion can be a great help, whether this is based on annual assessment of all employees, or on asking for applications from all those who wish to be interviewed for promotion to supervisors. It is certainly important that the decision should not be based solely on the opinion of one man. Most, although not all, recommendations for promotion are based on the results of a three or six months' training course, for which the potential foreman is carefully selected.

Even the best scheme, however, can be of little avail if the manager takes the view that his decision is unchallengeable and that he need explain to no one why the decision was made. The best manager, scheme or no scheme, will take the trouble and have the courage to see, at his own request, any man who hoped for but did not get promotion. He may not be able to explain very adequately why he picked A rather than B and C, but an honest attempt to do so is well worth the effort.

joint consultation

We have a highly developed system of consultation at Works Council, Division Council and Central Council. These bodies, made up of equal numbers of appointed management representatives and elected

payroll representatives, discuss all matters not covered by a trades union agreement. Their mere existence, as an indication of management's intentions, is of some value, but over and above this their real value depends on the attitude of the people taking part and of the Works Manager chairman in particular.

We have a few councils who give their attention chiefly to burnt sausages in the canteen, the suitability of long service awards for women and men, and the state of the mess rooms. We have many others which also discuss promotion, youth training, the state of trade of the products concerned, and even the effect of the K.I.D. on output. The machinery and procedure is the same throughout, but performance and results vary greatly.

If managers look on the Works Council as a complaints committee, then that is what it becomes. But managers with the right attitude regard the Works Council as a useful opportunity to keep employees informed on what affects them and to get their advice and views, and perhaps most important of all, as an opportunity for people at all levels to tackle a works problem together, to think aloud and thereby allow all to see something of the sincerity of purpose that motivates them. The fact that Works Councils have only minor executive powers and duties, and are really only consultative, has little or no adverse effect on their value if they are vigorously and imaginatively led by men with the right attitude.

communications

Works Councils do not reduce the responsibility of managers and foremen for keeping their men directly informed about what affects them; whether it is changes in the production plans, or changes in the pay and conditions under which they work.

Unless these explanations are given it is unrealistic to expect the fullest co-operation and hardest work from employees. In a big organisation with a large number of levels, where the top does not know the bottom, this is a big problem and one which we may have tackled better with our payroll employees than with our junior staff in large departments. Committees, magazines, notices and even Company "newspapers" have a place, and the shop steward has a special part to play, but none replaces the need for the works and plant manager, and also the foreman, to talk regularly, and in a thought-out way, with the people under him. Methods vary widely, and the manager or foreman to whom this part of his job comes easily, needs no programme or special help in many cases. In others, the nature of the work may make informal communication difficult even for such men. There will also always be managers and foremen to whom this aspect of their job is less easy and natural, and they must be helped and encouraged to develop some system, however informal. This may range from a daily meeting of managers and/or foremen over a cup of tea, to a discussion every six weeks, led by a foreman and manager sitting on a tool box, for the whole of the off-going shift at overtime rates.

We have no Company scheme for this, because how it is done will be different in each place and circumstance. The Company can help by providing the necessary information and background thinking to the manager, so that he who knows the men also knows and understands the policies that affect them. Whether and how well it is put over depends on the manager's attitude; with us some do it well, many try and some hardly do it at all.

"staff" and "payroll"

In the past, following tradition in this country, our conditions of employment, apart from actual rates of pay, have been very different for staff and payroll employees: methods of payment by the hour or week rather than by the month, the arrangements for time-keeping, holidays and security have all favoured the young daughter in the typing pool rather than the father on the chemical process.

For payroll employees there have been opportunities for increases of pay with increases in skill or output, and there has been the opportunity to achieve staff grade status, but otherwise there has been no opportunity for an individual payroll employee to improve his conditions of service except for a small percentage who are promoted each year to full staff status. At that point, a sudden large improvement takes place in their conditions of service and a new scale of improved pay and conditions is open to them.

The limited opportunity for improvement of conditions with promotion in the payroll ranks, and the sudden improvement on promotion from payroll to staff, seemed to us out of keeping with the merits of those concerned. The incongruity of it has also been emphasised by the increasing number of skilled technicians crowding about the border line between payroll and staff.

We have accordingly made a number of changes in the conditions of employment of payroll workers and some in the staff conditions also. For instance, we have greatly improved the terms given to payroll employees who become redundant for any reason, so that they are now comparable with the terms for junior staff. We have also done away with the practice of "clocking" on or off for senior payroll employees in some parts of the Company. More recently we have also introduced for long service employees, whether on the staff or payroll, a scale of holidays over and above the present two weeks a year. Under this scheme payroll employees with 25 or more years' service will get three weeks' holiday per annum, and those with 35 years' service, whether on the staff or payroll, will get four weeks holiday.

The full benefit of such changes can only be reaped if added privileges and responsibility go roughly hand in hand. Changes of attitude do not take place all at once, so that changes in conditions must be made slowly and in some reasonable relation both to national conditions and to the development of individuals. The latter is, of course, a major responsibility of management and again one where new ideas and attitudes can only be developed gradually.

management

We hear a lot, and I have said a lot, about management, and probably most of us have roughly similar

ideas about who we regard as managers whatever a man's title may be. However, I am glad to say that in my Company there is no clear definition of who is a manager and who is not. I like to think of there being an element of management, however small, in everybody's job and that this element gradually increases as one goes up the scale, rather than suddenly appearing at some closely defined point.

The man on the shop floor learns to manage himself and his tools and machines, then steadily responsibility for other people grows right up through to chairman. In all positions a man must make decisions; on the use of tools and doing the job at one end; on the disposition of people at the other. In making these decisions, and make them he must, he must obtain all the help and consider all the factors that are relevant. As responsibility grows those factors are more and more concerned with human beings and their reactions, and the ways of getting the best out of them.

To this end a manager must continually put himself in the other man's shoes. It can be argued that this is a dangerous thing to do: the forces around one are different, the background is different. I accept that there are differences. I believe, however, that there is more similarity between most of us than dissimilarity. We all like recognition; we like to belong somewhere; we like to be needed; we are wary of change that affects us; we don't like losing face; our behaviour in a group is different from what it is when we are alone; we don't like being reprimanded; doing a good job gives most of us some satisfaction.

In dealing with a number of people it is important to remember that they are made up of individuals and not the suspiciously motivated "they". In explaining or talking to them the question is: "how would I put it over to him?".

One of the most baffling problems of management is the special treatment of an individual against a background of justice for all. How often have we all heard the cry "it isn't fair", not only in our own homes but in industry too! Inevitably, especially in a large organisation, we must from time to time hold back from doing for one individual what we regard as right because it would be regarded as unfair by the mass who cannot readily know and appreciate the details. Before taking such a decision, however, let us make sure of the facts, weigh them carefully and before doing the "wrong" thing, recognise clearly why we are compromising. Over and above this, surely one of management's main objectives is so to alter the climate of opinion that compromises become less necessary and the "right" thing is more easily done.

In dealing with these and other problems, both courage and high standards are needed. For instance, the courage to consult before taking decisions. It is easy to tell the shift to work overtime if you don't know that it is Jack's daughter's 21st birthday. It requires more courage, and it may be necessary, to tell him to work overtime when you do know; it may also be rather more acceptable to him when at least he knows that you knew before you decided.

Our standards, too, must always be high enough to get the best out of the majority, rather than low enough to cause no strain or embarrassment to anybody.

management development

It is much easier to say what is needed of management than to say how to meet the need. Selection for management is obviously of great importance and I have little to add in this branch of business which is so active to-day. One has, however, heard it said that scientists do not make good managers, and I should like to state that we have not found this to be so. In the chemical industry the chief need is for scientific and technical managers. Intelligence and good education are needed for the scientific and technical work and we believe that both are great assets in the development of good managers. Especially do we find that they contribute to the lasting qualities and continued flexibility of managers, as well as to their ability to see the wider issues and to make moral judgments.

Training and development of managers is a popular theme to-day. Clearly there is no right or wrong method, but inevitably the most important element is what the man learns from those about him and especially those above him in the day-to-day course of his job. This may be good, bad or indifferent and a good historical background is a great asset. Where this does not exist, progress must be slowed down and efforts must be increased to bring other forces to bear. These forces include the Company's personnel officers, trade union officials, training courses or conferences either organised by the Company or by some other body, and the stimulus provided by research in personnel matters.

One of the most important duties of personnel people, especially in large companies, is to help managers to develop along sound lines by stimulating and challenging them so that they are forced to focus their attention on personnel matters. To play an adequate part in this they must be of such calibre that their views are sought and valued by managers, and they must be wise enough to resist any tendency for a manager to leave personnel decisions to them.

A lively and forceful trade unionist can also play a large part in the development of a good manager, and a judicious transfer may be able to put him in the way of this rewarding experience.

Mr. Lewis Wright spoke last year of the role of research in human relations and the need for more of it, and I would particularly stress the need for making more readily available to managers the results of such research, past, present and future. It is still quite unnecessarily difficult for a busy manager to sift the wheat from the chaff and to find simple explanations for much research work. If this had been easy it would have been done, but it is worthy of greater effort than appears to have been expended so far.

Finally, there are a host of management training courses and conferences to choose from, as well as those often run by the larger companies for their own people. The increase in such training opportunities since the War has been phenomenal and, considering

this rapid growth, their quality has on the whole been remarkably high. The disappointing aspect of this development has been the relative lack of support received from the smaller companies and from certain sections of industry, in spite of numerous attempts to bring them in.

One recognises that it is more difficult for the smaller units to spare their men and that they may feel it is easier for them to train their own men on the job in the way the managing director wishes. This may be a good way or it may not be, but in the latter case the managing director can hardly be expected to think so. However, progress is being made in training managers from all kinds of companies and industries and no doubt this will continue.

In nearly every case to-day the training includes very little dogmatic instruction by tutors or lecturers. Most of it is self-education by exchange of thoughts and experiences between the students and by the critical examination of situations with skilled but unobtrusive guidance from the staff. The content and techniques, however, vary widely, as they are designed to meet the needs of managers of very different seniority and experience. I believe much of the benefit derived from courses resides in a greater awareness of and respect for the views of other people, and in the opportunity to sit back and think consecutively of one's problems with the help of other people. If a manager returns from a course with a feeling that he has a real responsibility to work out even some small part of his policy and attitude towards those below and around him rather than to follow a book of rules, or to leave the job to the personnel officer, or just to leave it to chance or blindly follow what he thinks his boss wants, then quite a large sacrifice of time and money will have been worth while.

conclusion

I have covered much ground and inevitably, very thinly. I have tried to describe some of the history of my own Company and the things they have found it worth while to do in the realm of human relations. No doubt many of these could have been improved and many would not be appropriate to other companies in other industries at other times. I have, however, tried to bring out at all stages that valuable though these actions and arrangements have been to the Company, it is the spirit behind them and the attitude of one man towards another throughout the Company that is of the greater importance. This must be universally true for all companies and organisations and I can only hope that here and there I may have presented an old truth in a light which is new or stimulating to some of you, so that we may have a lively discussion.

REPORT AND DISCUSSION

In the Chair:
MR. HAROLD BURKE, Vice-President of the Institution

THE **Chairman,** on behalf of the Institution, welcomed all those attending the meeting and thanked the authorities of the University of Bristol for placing such excellent facilities at the disposal of the Institution for the presentation of The 1959 E. W. Hancock Paper. They were all, he said, delighted to see present Mr. E. W. Hancock, whom the Paper was designed to honour.

Mr. Hancock had given long and valuable service to the Institution, where he was one of the most outstanding personalities. He was not quite a founder member, but might almost claim that distinction, for as long ago as 1930 - 1931 he had been Chairman of the Council. It was difficult to imagine, looking at him today, that he had been old enough at that time to be a Member of the Council, let alone its Chairman.

Since then he had given distinguished service to the Institution. He had held office as National President in 1956. He was a founder member and Past President of the Wolverhampton Section and a Past President of the Coventry Section. He had always placed great emphasis on the training of young engineers, and had been responsible for advocating the policy which had been responsible for the establishment by the Institution in 1949 of the Schofield Travel Scholarships.

In 1958 the Council had felt that it would be right to honour Mr. Hancock for his very long and distinguished service; and, knowing that his interest in human relations had always been paramount, it had been decided to institute in his honour the annual presentation of a Paper on this subject. It was to be hoped that Mr. Hancock would contribute to the discussion of the present Paper, because he had always something worthwhile to say and it was always a delight to listen to him and to benefit by his mature experience and wisdom.

The 1959 E. W. Hancock Paper, which was now to be presented, was entitled "Human Relations in Industry" and was by Mr. R. A. Banks. Mr. Banks was at the present time Director in charge of Group C (Ammonia and Agriculture) of Imperial Chemical Industries Ltd., and had formerly been Personnel Director. The details of his career were given briefly in a note preceding the printed Paper. It was clear that he had had a long and useful experience, and they would all be most interested to hear what he had to say that evening.

Mr. Banks then presented the Paper which appears on pages 2 - 7.

Mr. E. W. Hancock, O.B.E., Hon.M.I.Prod.E. (extreme left), Past President of the Institution, in whose honour the Hancock Paper was established, chats with Mr. Harold Burke, Vice-President of the Institution; Mr. W. F. S. Woodford, Institution Secretary; and (extreme right) the speaker, Mr. R. A. Banks, at the reception preceding the lecture.

The **Chairman** said that, as was to be expected from his Paper, Mr. Banks had stimulated some lively thoughts in the minds of his audience, and it was to be hoped that an equally lively discussion would result. This problem of human relations was one which they talked about a good deal but understood, perhaps, a little less, and action was perhaps sometimes even smaller. They had, therefore, to guard against the possibility of paying lip service to what they believed to be the ideals of human relations without making much effort to put them into practice. Mr. Banks had described his own outlook as one of humility, but it was the members of his audience who had come to learn and acquire some lessons which they could apply.

The discussion would be opened by Mr. Bernard Stokes, who was currently Chairman of the Institution's Editorial Committee and responsible for the organisation of the Journal. He had been one of the first of the Institution's Schofield Travel Scholars, and it was appropriate that he should be invited to open the discussion.

Mr. B. E. Stokes said that it did not require much reflection to appreciate that good human relations were necessary whenever more than one person was involved in doing anything. Within industry, where many people were each carrying out some individual task of significance to the purpose of the company, the lack of good personal relationships must inevitably result in chaos.

In his excellent Paper Mr. Banks had emphasised and demonstrated that the main contribution towards good human relations was a personal one, which sprang from the right attitude of mind. It was, however, difficult to define the right attitude of mind without bringing in conceptions such as understanding and tolerance, words which were themselves difficult to define.

There was also the fact that while the determination of an attitude of mind was a personal problem, the answer to which reflected individual assessments of life's value and purpose, these answers were not all entirely personal matters, because the impact of each personal decision might mean either the enrichment of life, in the best circumstances, or the destruction of life, in the worst circumstances.

Despite the obvious importance of good human relations there was a tendency to take the problems of human relations largely for granted. To take a simple illustration, a man who was buying a house would be considered inept by his friends if he did not consider the matter most carefully, obtain appropriate advice and so on. In a very personal matter, however, the same man, if contemplating marriage, would receive the heartiest congratulations of his friends on merely informing them of the vital statistics of the young lady of his choice.

There was certainly a tendency to measure problems of human relationships in rather superficial terms, perhaps because the relationship was difficult to define and because the personal qualities involved were rather abstract. Possibly because of this, the problem of the personal approach, the attitude of the individual, was that part of the human relations problem about which least was known.

The second part of the problem posed by Mr. Banks was concerned with the action which a company could take in order to create circumstances which both encouraged the right attitude, and ensured that the available pool of goodwill of its employees was used to the best advantage. In this respect the ground was somewhat firmer, because experiment and experience could be defined in more concrete terms of organisation and administration. Despite this, and possibly because of the difficulties which arose regarding the first part of the problem, it was not all that unusual to find that the organisation of a company and the formal definition of the responsibilities and relationships of the various activities which formed the company hindered rather than helped good personal relations, and created rather than resolved conflict.

This was often reflected on the shop floor. Those who had tried to put in a production control scheme with an incentive system would know the kind of conflicts which could arise simply because the objectives of the plan did not correspond with the objectives of the incentive scheme. Equally, at a higher level, differences in policy could create considerable conflict. For example, the problem which arose when the financial director said "We must

maintain our work in progress at a given level ", and the production director said " Process batches are not big enough; we must make them bigger ", must inevitably lead to difficulties on the shop floor with adverse affect upon human relationships. Conflicts arising from differences of objective or purpose must result in conflict on the shop floor.

Reference was made in the Paper to the importance of research in this field of human relations and also to the difficulties which sometimes arose in endeavouring to apply the results of the research which had been carried out. One could sympathise here, because the work of psychologists was not always easy to follow, but, leaving that aside, difficulty in getting the appropriate research done and in understanding some of the research which had been done might arise from the lack of demand from management for stuff which they could understand and apply. Was the right kind of pressure being exerted on the people who did the research, or were they having to operate, as it were, in a vacuum, without knowing from management the types of problem to which answers were required? In that respect it would be interesting to know what Mr. Banks would suggest, in the light of his experience, as fruitful specific fields for such research.

Finally, one of the most useful points in the Paper was the reminder that Mr. Banks had given that each one of them was indeed his brother's keeper.

Mr. Banks commented that Mr. Stokes had given almost a second lecture, which was extremely important, valuable and debatable. There would be general agreement with Mr. Stokes's statement that there was no unanimity on what was the right attitude to adopt. It might be wise to recall what Mr. Hancock wrote in his 1956 Paper, that it was necessary to look to the good Lord for the answers to these problems; they were written in the Book. Unfortunately, there were many interpretations of exactly what He did say and what He meant by what He said, but it was a good source to which to go for information and inspiration.

Mr. Banks agreed with Mr. Stokes that the greatest difficulty was due to lack of thought about personal relations. Mr. Banks knew how often he had found himself doing something or taking some decision and neglecting to think about the effect on some person or persons who would be affected by it. That might happen several times in the course of a single day. Even if they were not quite sure of the answer or of the attitude which they should adopt, the mere fact of thinking, more than they did at present, about the attitude which they ought to adopt would take them a very long way along the road. Even if they were not all good Christians or good Buddhists or whatever it might be, if they thought sincerely about the effect of their actions, they would get much closer to the right answer than if they gave no thought to the matter at all.

Mr. Stokes used rather a nice phrase, but one in which Mr. Banks would join issue with him, in saying that conflict destroyed human relationships. He felt that that was wrong attitude to conflict. Conflict strained and challenged human relationships but did not necessarily destroy them. Life was made up of conflict. How did a man resolve his loyalties to his trade union, to his boss, and to his wife and family ? On the management side also there were conflicts, but they did not destroy human relations but tested them and, if they survived the test, those human relations were tremendously improved. Without conflict life would be a dull, milk-and-water affair, and it was not. The only trouble was that many conflicts were beyond the powers of ordinary people to solve; but, when a conflict with a trade union or with an individual was satisfactorily solved, there was not likely to be any more trouble for a very long time. That might not often happen, but, when it did, it was a most rewarding experience.

Mr. Stokes had also asked what should be done about research and whether or not they gave the research workers enough of the most important problems which were affecting industry. It was probably true that they did not, But Mr. Banks' problem was that he was not sure which were the most important ones on which to do research. He believed that those who were nearer to the problems than he found himself today could do tremendously valuable work by putting those problems forward. He felt sure, for instance, that if the Institution, by setting up a study group or in some other way, could produce a fairly concise priority list for research, it would be warmly welcomed by anyone who was concerned with and conducting research in this field. He had been a member of the Council and Research and Executive Committee of the National Institute of Industrial Psychology, a body very much concerned with this field, and they would, he was sure, be very grateful indeed for help of that kind. He had not the answers, but he thought that the Institution could obtain them, and if he could persuade the Institution to do so, the evening would have been well spent.

Mr. I. R. Smith (*Chief Inspector, Bristol Aircraft Ltd.*), said that the important subject of human relations was one about which they were all endeavouring to learn more. His own Company was probably as fortunate as that of Mr. Banks in having a history of good relations, probably due largely to the growth of the Company from a small unit to a large organisation without loss of family interest. The existence of personal interest at the top had built up trust between managers and men and this had continued over the years. As a comparative newcomer, of four or five years' standing, he had found this very noticeable.

He was very much concerned with human relations and with making everyone realise that he or she had a part to play in the running of the department. This had been brought out by Mr. Banks in referring to an element of management in everyone's job. A man's interest in his work was an essential factor in production, but the structure of modern industry was so complex that it was almost impossible for the

average worker to associate himself with the fortunes of his employer. The circumstances in large manufacturing organisations were such that a man might easily feel that he was an unimportant member rather than a vital contributor. No effort should be spared to overcome this feeling, because its effect could be damaging.

Direct lines of communication between top management and employees must be established and maintained, and every scrap of information which could be given on the progress or otherwise of the firm should be passed down. It should be impressed on every worker that he was part of the production team and that his contribution was of vital importance.

It was easy to appreciate that the maintenance of good human relations in a large industrial organisation was difficult. In a small firm, personal relationships were on a more intimate footing. The unwieldy size of some present-day organisations, however, should not render management remote from those whom they employed. It would be a contribution to the solution of the whole problem if each individual who was responsible for the control of others would get to know the abilities and shortcomings, the strength and the weakness, of those whom he controlled. In that way it should be possible to ensure that no individual was embarrassed by being given a task which was beyond his scope.

Mr. Banks welcomed the support of Mr. Smith, given on the basis of the experience of his Company, which must, Mr. Banks felt, be a fine company for which to work. In a production job such as that Company was doing there must be even more problems than were found in I.C.I., or at any rate different ones. He agreed with Mr. Smith that one of the important jobs that the manager had to do was to know the strengths and weaknesses, the limitations and abilities, of those under him.

Mr. Banks' only doubt concerned the extent to which in fact most people were capable of doing this. He thought that there was sometimes a grave risk of writing down the abilities of people under one who did not fit into a pattern to which one was accustomed. In saying that he had his own feelings very much in mind. He found it reasonably easy to judge the abilities and weaknesses of someone in a certain rather narrow field, but he had never been a very good salesman and he found many very good salesmen very difficult to evaluate. They had qualities, strengths and weaknesses, which were not his own, and he would find himself a very diffident judge of them. That was an extreme example. He was sure it was right to say that managers had to try to do this, but, outside a certain field, it was one of the most difficult things that they had to do. They could feel confident in their judgment of certain people but not of others, and they had to beware of being too convinced and relying too much on their judgment, particularly when dealing with people with backgrounds and approaches different from their own.

Mr. A. Eustace, Honorary Secretary, South Western Region (extreme left); Mr. T. E. Love, Gloucester Section Committee (centre); and Mr. W. U. Snell, Western Section Committee (second from right), chat with guests at the reception.

Another speaker, returning to the question of conflict raised by Mr. Stokes, wondered whether or not Mr. Banks had glossed over it in view of the very clear policy of his Company in this field, which differed from that existing in some other organisations. It was probably true to say that many companies regarded the fostering of conflict between senior executives as something which was most desirable, and there it was taken to even greater limits than Mr. Stokes had mentioned. Mr. Stokes hinted at difficulty in reconciling the views of the financial director and the production director. That was natural in any organisation, but there were some organisations where the matter was taken much further and in a much more subtle way.

Personally, he regarded failure to define functions and responsibilities as a way of fostering conflict in the no-man's-land which remained undefined between the jobs of the various executives. It was said that to define a manager's responsibilities too closely meant limiting and cramping him, causing him to become discouraged. He himself felt that that was wrong and that the precise definition of responsibilities was desirable. He believed that the greatest works of art had been created in circumstances and forms where the definition of limitations had been quite severe. In the industrial sphere, men who were given clear definitions of their responsibilities and functions could still produce their best achievements and do so in the secure knowledge that if they wanted to stray outside their field they must ask somebody; it was not a question of doubt whether or not they could do it without someone realising what was taking place. It would be interesting to have the comments of Mr. Banks on this, because he believed it to be a definite philosophy of management, though probably not admitted or defined as precisely as he had tried to define it, which motivated the policy of certain companies.

There was another matter on which he would like Mr. Banks to comment, namely, the attitude of his Company towards social meetings with trades union officials. Were the shop stewards brought in on these occasions and, if not, was there any danger of such a

Mr. Bernard Stokes (right), **Chairman of the Institution's Editorial Committee, has a serious discussion with Mr. A. Eustace, Honorary Secretary of the South Western Region, before the meeting.**

policy contributing to the gap which certainly existed in industry between the whole-time officials and the shop-floor-elected representatives of the trades unions ?

Mr. Banks did not feel that he could make any contribution on what was to him the startling proposition that boards of directors sometimes stimulated conflict, presumably on the lines of which the British Raj had been accused of " divide and rule " as between Hindus and Mohammedans. When functions and responsibilities were not clearly defined, it certainly gave room for conflict of that sort. On the other hand, there were organisations where responsibilities were not very closely defined and where there were overlapping responsibilities, but where conflict did not necessarily arise. He could quote the case of his own Company. They were not very rigid in their definition of jobs. The Board of I.C.I. had rather an unusual structure, though one which was not unique. It had a two-layer structure, in that there were five functional directors, responsible for research, development, commerce, finance and personnel; and five or six group directors, each one of whom was responsible for every operation in a particular group of factories. There was therefore in theory every possibility of conflict, in that at least two people on the I.C.I. Board were responsible for everything that was done.

One important reason why it worked as well as it did was because almost all the directors had spent virtually the whole of their working lives in the Company and knew each other's strengths and weaknesses and peculiarities. If it were a smaller company, where it was not possible to have the same promotion from within but where people had to be brought in from outside, he thought that it would be doomed to failure. That was one of the reasons why it was possible to adopt different degrees of definitions in different companies.

On the whole he was in favour of the definition of responsibilities, but equally of leaving within those responsibilities as large a measure of freedom for thought and action as possible.

With regard to his Company's attitude to social functions with trades union officials, it was not possible to generalise very much about a company such as Imperial Chemical Industries. So far as it was possible to generalise, they had recognised shop stewards only fairly recently in their history. They had now been recognised and did exist, but there was no shop stewards' committees so far as he knew; they had less power, standing and authority than they appeared to possess in some other companies and industries. The social parties about which he had spoken were confined entirely to the permanent officials of trades unions. There were many opportunities for social occasions with employees, including shop stewards, but he did not think that shop stewards had ever been singled out for a social occasion. There was a system of joint consultation, to which the unions were free to nominate representatives and did so. They came in, therefore, not only for formal joint consultation but for social occasions, but they were not brought in separately and they were not the force in his Company that they were in some other industries.

Mr. V. Eaves welcomed the fact that Mr. Banks had put the emphasis on personal relations and not on personnel and asked whether or not he would agree that, while personnel officers were desirable to direct thought on the subject and set the tone of the work, the only people who could direct personal relations were the floor management.

Secondly, on the question of good relations with the trades unions, were I.C.I. in the peculiar position that, having created a family atmosphere, they could reach agreements on their own? In his own industry, he said, they had very good domestic relations, but in reaching agreements they had to ask somebody else, and it was there that their problems arose. Domestically they could do much better, but everything had to be referred back and that bedevilled the problems.

Mr. Banks entirely agreed that the manager who knew about the job and managed it was the man to set the right attitudes regarding personal relations with the men, rather than the personnel officer, but said that it was the job of the personnel officer, when that was not done, to stimulate or prod his manager to think of that aspect of his job. Even the best managers, or at any rate the second-best, missed tricks occasionally, however well-intentioned they might be, and should be grateful for prodding by

the personnel man, who might ask: "Have you thought about Jack's wife?" or about the reaction of the shop stewards and so on. But the responsibility was that of management, and in I.C.I. they held that very strongly indeed. The responsibility of the personnel man was not an executive one, but he should act as prompter, adviser and helper.

In their relationship with the trades unions his Company were lucky in many ways. They did not negotiate wages and conditions through an association or organisation of employers. The reason was not so much that they did not hold with doing so, as that they represented such a large part of the chemical industry, which was represented by an organisation of employers which negotiated for the rest of the industry, that they felt that they would be very uncomfortable bedfellows for them as one big organisation among a lot of smaller ones. They might be accused of using the big stick to coerce them or might be falling over backwards to conciliate them. They got on very well with a system which had sometimes been described as companionate marriage.

It should be mentioned that the Chemical Workers' Union was not one of those with which they negotiated and did not represent a substantial proportion of their employees.

Mr. Edwin Fletcher (*Secretary, Production Department, T.U.C.*), speaking as a trades unionist, said that the Paper was one of the best on its subject that he had ever read. The subject was one on which it was easy to generalise, but Mr. Banks, by drawing on the experience of a large company and by having a definite philosophy, had produced a Paper which contained a tremendous amount of material for discussion. He did not think that that was an accident. I.C.I., as a large Company, could not afford to have its equipment wasted by trouble due to inadequate industrial and human relations and, therefore, spent money on them.

It seemed to him that this country was facing a change in industrial relationships. It was possible to continue the old idea of "hire and fire" or adopt an entirely different approach to the problem, as was possibly done by many firms represented that evening. Such an approach was essential at the present time. Automation, for example, required *consistent co-operation from a team.* With steadily increasing mechanisation, the old idea of "hire and fire" could survive in this country only as a tribal custom. Mr. Banks had described what had been done by I.C.I. in changing industrial relations and had shown something of his own philosophy. Would he care to give his interpretation of the way in which industry would have to develop, and in particular would he expand the "staff and payroll" paragraphs of his Paper, with regard to possible developments within I.C.I. Ltd.?

Mr. Banks replied that the subject was a vast one. He hoped that he had given an outline of their thinking. It started by looking at individuals as individuals and wondering why people had to be segregated into sheep and goats, staff and payroll. That was the one finite distinction which they had between their employees, because, as he had said already, they did not regard management as starting at one particular point and stopping at another point. It blended in, and if anyone were to ask one of their people how many managers they had it would be impossible to give an answer, or no two people would give the same answer.

On the other hand, to the question of how many staff they had and how many members of the payroll they had it would be possible to give a specific answer; and the same answer, if people did their sums right, would be given by everybody. It was the one absolute cleavage. It seemed to them utterly illogical that there should be any such hard and sharp line of division as that. There was no doubt that it became more and more illogical in this age of high specialisation. There were more and more people in the employ of I.C.I. who were clustered about this line of demarcation and who might be either staff or payroll — the estimators, the charge-hands and an increasing range of others. There were fewer and fewer hewers of wood and drawers of water and more and more technicians, technologists and so on.

They had felt for a long time that something should be done about it and that there should be one continuum, without this sharp break, from the boy who was brought in to wash the bottles in the laboratory to the Chairman of the Company. That was not synonymous with saying that they should all be on the same basis or that they should all be staff or all payroll. Ultimately they should all be employees; in other words, they were all employed by the Company. He disliked titles intensely unless they described what a man actually did, and the titles "staff" and "payroll" described nothing at all. A member of the staff might be working with his hands and a member of the payroll almost entirely without using his hands, so that there was no justification for the distinction, but it was traditional in this country and in his Company.

His Company had, however, started gradually to try to reduce some of these differences. It was not something which could be done all at once. There were tremendous in-built resistances of all manner of kinds. The staff disliked having their privileges encroached upon and the payroll people disliked having their conditions changed. Sometimes their conditions were better than those of the staff and sometimes they were worse. There was a host of difficulties and the problem could not be solved quickly. Each step which was taken had to be rewarded by some benefit which accrued from it. The steps tended to be costly, and to avoid inflation it was necessary to get value for money by increased productivity or better time-keeping, or whatever it might be.

One step which they had taken recently had been to introduce a scale of annual holidays. Until recently members of the payroll had a fortnight a year, while members of the staff had anything from two to four weeks on a complicated basis involving length of service, salary and so on. They had done something

recently to try to bridge that gap and had introduced, for instance, four weeks' holiday for everybody, staff or payroll, with over 35 years' service. It might be thought that that was a theoretical concept, but in fact they had a very large number of people with 35 years' service on both staff and payroll. There was a scale going down from that level. Not all the steps were the same for staff and payroll, as people with higher responsibilities needed a longer holiday. They had, however, adopted a scale. He did not say that it was the right scale, but it was a scale with a series of steps in it rather than one abrupt step between staff and payroll. It was impossible to get the right solution because of all the in-built difficulties in the current system.

A number of other steps had also been taken towards a more logical system of conditions of employment for employees of all ranks. A programme for further development along these lines was envisaged for the future. It was not, however, one to be quickly carried out; that would be wrong, because it would lead to bad compromises in order not to upset people, and the position might be made worse than before.

Mr. R. W. Hancock (*Past Chairman, South Western Region*), who regretted that he could claim no relationship with his illustrious colleague after whom the Paper had been named, said that there was one point in the Paper, and to which Mr. Banks had referred in his last reply, which had always worried him. Was it necessarily just and right, and so conducive to good human relations, to give any particular reward for long service ? Long-service employees were often people who had shown no particular loyalty to their company other than by remaining in their posts. They might simply be people with very little ambition. The man who did 20 years with one company, 20 years with another and 10 years with a third before retirement might be far more loyal to each of the three companies and have given far more useful service to all three. Was too much attention paid in this country to long service ?

Mr. Banks welcomed the raising of this point. It was, he said, one of the soft spots where their armour was easily penetrated. His Company had in the past done very little for people with long service. They had given gold and silver watches, but a gold watch after 30 years did not add much to the overheads. Mr. Hancock, however, was quite right; the theoretical weakness of their scheme for holidays was that long service should not be the key factor.

There could be no doubt, however, that the rank and file paid very great regard to long service. That was built into the national life, and if something was done to reward long service the employees generally regarded it as right and proper. If his Company had said : " Each man will be judged by a panel of three people immediately above him to determine how much holiday he should have, between the limits of two and four weeks", it might have been theoretically the right approach but would have given a great deal of trouble all round. The Company had to choose some criterion which would command general approval, and so adopted length of service.

Mr. Wansborough-White speaking of the reference in the Paper to promotion policies, put forward the suggestion that a man was made up of three personal qualities. First, he had ability, which might be designated by A, made up of native intelligence, education and experience. Secondly, there was his willingness to work, W. Neither of those qualities was very much use without taking into consideration a third and very important factor : H — human relations. A man could be very able and well educated but show no great willingness to work; while another man might score more under W and not much less under A. In choosing between the two, what would matter in the end would be H : human relations.

Was enough notice taken of those three qualities ? The first, A, was essential, but it was not enough for a man to be able and intelligent; he must also be able to work hard and willing to do so. An able man who would not work was no use, any more than a man who worked like a beaver and had no intelligence. Most important of all, however, was his ability to get on with his fellow-men. Everyone must vary in values of A, W and H, but it seemed to him that not sufficient account was taken of this.

Mr. Banks said that nothing was ever taken sufficiently into account, because nothing was perfect. The subject was extremely complicated. Although all the three qualities which had been mentioned were extremely important, he thought it would be agreed that their relative importance depended very much on the job to be done. In the case of a research worker working entirely on his own, or at the most with two or three other people, human relationships were not so important, but he could be, in theory, the most important person in the company. A certain amount could be done in making use of a man's strong points by directing him along certain paths. In any company there would be plenty of examples of promoting people along the wrong path, and people who might have been very valuable in some sections had been such a nuisance elsewhere that they had had to go. That was bad casting. The job was rather like choosing people to take various parts in a play, but was more difficult, because the industrial play ran for ever.

An even more difficult aspect of the problem was that in a given line of promotion certain qualities might be needed at one level, but a different balance of qualities might be required at the next level, going back, perhaps, to the first balance at the next level after that. He could think of a number of cases where people had been promoted to a job at one level above their own and had not done very well, but had done much better in the job above that to which they had been promoted later. The problem, therefore, was more difficult than had been postulated. What the answer was he did not know. It might be that industry in general paid too little regard to the blending of the necessary qualities.

There were places where technological virtuosity was the be-all and end-all, and no doubt the questioner had that sort of case in mind, but there were others which resembled the case history he had quoted, where a kindly, paternalistic employer had been running a company and not making a profit. Such a man had plenty of H, but not much A, and probably not much W either.

Dr. G. S. Brosan (*Head of Department of Engineering, Willesden Technical College*) recalled the answer given by Einstein when asked to give a formula for success. Einstein said that it was X + Y + Z, and, being asked to define his terms, explained that X was hard work and Y was playing hard. On being asked what Z stood for, Einstein replied: "Z is the ability to keep your mouth shut".

His own occupation was not in industry but in education; there, too, there were certain problems of human relations, and in that connection he had had a very illuminating experience. On one occasion he had acted as a salesman and had found, to his surprise, that salesmen had to face much the same sort of problems, on a somewhat different level, that he was facing every day. The question which he would like to ask, therefore, was this: did Mr. Banks think that in the problem which they had been considering there was anything to learn from the attitude of the salesman? He had in mind the really good salesman, not the door-to-door tout. Did Mr. Banks think that the salesman's idea of "one-sidedness", of trying to identify himself the whole time with his customer, could give a different lead from the rather two-sided approach which had been discussed that evening? There was a tendency to say: "We are the management"—or "We are the human relations people — organising the people in the works".

Mr. Banks said it was a very interesting idea to bring in the qualities required in a salesman, and certainly putting himself in the other man's shoes was something that the salesman had to do, but there were probably differences. The manager had to think man by man, but in order to add them up into a bunch. In saying that, Mr. Banks felt that he was trespassing in the field of mass psychology and bringing in the theory that people acted differently in the mass from the way in which they would act individually, and he had emphasised earlier the importance of studying a man as an individual. He felt sure that to a considerable extent the attitude which salesmen had to adopt, and the way in which they had to think of the individual with whom they were dealing, were pertinent to the problem of the manager who was managing a bunch of men, but he suspected that equally there were very large differences. He did not know enough about the sales side to express an opinion. One was apt to think that certain people ought to be able to do certain things very well and in practice one found that they could not.

He did not know what the answer was, but there was a different sort of discipline, or indiscipline, and it just did not work. There might be some hidden fallacy in the idea that a salesman would make a good works manager.

Mr. Ellam referred to the statement in the Paper that "A staff grade scheme was introduced in 1928 which gave increased security to 25% of the hourly-paid employees with five or more years' service", and said the important point was that "they received their full weekly wage when sick and unable to work". In later years the percentage had gone up from 25 to over 80. Did Mr. Banks think that this extra money was still well spent?

Mr. Banks replied that the answer was, as so often, "Yes" and "No". His Company had no desire at all to go back on this scheme; on the other hand, it had been a bigger challenge to good management than so far they had been able to meet entirely satisfactorily. There were signs that a proportion of the people affected took more time off than they should. It was extremely difficult to get to the bottom of the problem and analyse it to everybody's satisfaction, but it might be that a certain number of people did not act up to their responsibilities. It was a challenge to management, and management in his Company as a whole were aware of the fact that it had not been met 100%. A number of attempts had been made to deal with it and it was hoped in the end to do so satisfactorily.

In the last five years, with their eyes wide open they had increased the scope of the scheme. Up to that time there had been an artificial limit of 50%, to which it had been increased from the original 25%. It had been obvious, however, that 50% was the wrong place to cut it off, because if there were a Gaussian distribution of qualities, then at 50% there was little difference between the best who were not on staff grade and the worst who were on it. It was not considered possible to put the clock back and reduce the limit below 50%, and so they had set themselves the challenge of going above it and still getting good value for money. The scheme now covered 80% of those eligible.

Mr. A. T. Shadforth (*Personnel Officer, Bristol Aircraft Ltd.*) said that in the Paper Mr. Banks had touched on the problem of line managers leaving personnel decisions to specialists, and other decisions coming within the province of specialists to those specialists. This was a problem encountered in many organisations in this country and one which it was very difficult to overcome. It would be interesting to know what methods were used in Mr. Banks' Company to ensure that line managers did not make this distinction, which was so easy to make, between the technical side of their work on the one hand and the administrative side, which so often covered personnel management, on the other. Did the Company, for instance, have personnel officers in remote parts of the factory, so that they were "un-get-at-able", or did they provide the managers with copious Rule Books so that there was no need to go to the personnel officer, or was some training given in management courses to encourage managers to gain knowledge and confidence in this part of their work?

Mr. Banks explained that it was difficult to generalise, because different systems were used within the Company in allocating personnel officers, but in no case were they sent to remote parts of the factory where they were "un-get-at-able". One thing which emphasised the manager's responsibility for personnel matters was that in the Works Councils and Production Committees the personnel man was always the secretary, sitting there quietly helping, but not the Chairman of the meeting. Management was forced in that way to accept responsibility for the kind of thing that Mr. Banks was attempting to do at the moment, namely, put something across to the body of the meeting. In general, they had succeeded, more in some places and less in others, in making the manager proud of the fact that it was his decision and one which he would not allow to be taken by anyone else. That was done partly by giving the individual works managers as much latitude as possible within the framework of agreements with the trades unions. They had not in all cases done as much as they would like to do, but their works managers did have a good deal of latitude and could take decisions without referring to a book of rules.

The works manager was not generally an expert on the more erudite parts of the book of rules and had to refer to the labour manager, or whoever it might be, to put him right and keep him right on those matters. On the whole the policy had been successful, partly due to their long history and partly, as he had said, to giving the works manager or plant manager a good deal of opportunity to exercise his own judgment inside the rules. In trades union negotiations the works manager would be in the chair. Things of that kind continually emphasised that the personnel manager was not responsible.

Mr. R. S. Brown (*Works Director, Bristol Aircraft Ltd.*) said that the discussion had proved to be, as he had expected, absorbing, and he had very little to add except on one or two points. Several speakers had mentioned the necessity to keep the "other fellow" informed. He had taken steps to deal with that in his own factory as fully as possible. With regard to Works Councils, when in 1940 the late Sir Stafford Cripps introduced consultative committees into the aircraft industry, they had set up such a body. At the time, with all due deference to his friends from the trades unions, they had considered it to have a nuisance value and to be a possible means of blowing off steam. Since then, however, they had come to appreciate it more and more, and they now regarded it as a very valuable part of their organisation for ensuring good human relations and keeping their employees informed about what was happening in the factory.

He would be interested to know why Mr. Banks' Company had equal representation of management and workpeople on the consultative committee, with the manager as chairman, because that seemed to imply that importance was attached to equal status although the body was not given any executive authority. In his own Company they had always maintained that there should be fewer members of the management on the committee, so that the workpeople could have a greater say and a better opportunity to voice their views.

Mr. S. G. E. Nash (left), South Western Regional Chairman, is obviously entertaining Mr. H. R. Priday (centre), Secretary of the Bristol and Bath Productivity Association, and Mr. F. M. P. Adcock, Bristol Area Manager, I.C.I. Ltd., at the reception.

Mr. Banks did not think that in his Company a great deal of thought had ever been given to any other representation than 50 : 50, but said he could give the assurance that that had not in any way inhibited free discussion and free expression of opinion by the workers' representatives on Works Councils. He had heard quite violent attacks on individual members of management present.

There had never been any suggestion that Works Councils had executive power, except in regard to the limited schemes run by them for the distribution of funds subscribed by the men, and so on. He thought it would be hopeless for them to have such power. What kept them alive, and the only thing that did so, was people seeing that something was done as a result of matters raised by members at Works Councils. They had had their ups and downs and there had been suggestions that they should be abolished, but he was convinced that they were still doing a good job and he believed that they were improving. He thought that that improvement was due to the fact that more attention was being paid to management training in the usefulness and value of Works Councils and to getting the Chairmen of different Works Councils to meet together from time to time and swop ideas. Some people would always run first-rate Works Councils, while others found it less easy and their Councils were less effective; but by getting people to exchange ideas his Company had gradually raised the standards and the Councils were now functioning better than they had done for quite a number of years.

The **Chairman** said the fact that the discussion had gone on for 80 minutes without any gap between speakers indicated the very real interest taken in the Paper and the subject with which it dealt. Before closing the meeting in the traditional manner, he knew that everyone would like to have a word from Mr. E. W. Hancock.

Mr. E. W. Hancock, O.B.E., said that he had been inspired by the way in which the subject had been dealt with, both by the lecturer and in the discussion which has followed. He thought it was a good thing, once a year, as most of the Papers presented to the Institution were of a technical character, to have an informative Paper on human relations and a discussion thereon.

It was nice to know that present at this gathering were people such as Mr. E. Fletcher, of the T.U.C., listening to and participating in the evening's discussion.

Many of the principles which had been enunciated this evening would, he prayed, go beyond industry. Personal contacts leading to "summit conferences" were all part of good management, and he was delighted that this evening many references had been made concerning the importance of personal contacts in industry.

He hoped that there would be more "summit conferences" with all sides of industry, as industry had become so completely interrelated and interdependent that a fire or a strike, small in itself, affected the whole.

The word "industry" was used in the title of Mr. Banks' Paper and to define what is meant by industry, we had to visualise 9,000,000 people working in 56,000 factories; three-quarters of them employing less than 100 people. All these factories were in one way or another interrelated and, therefore, needed the best possible human relations to obtain supplies in order to keep British industry thriving.

Mr. Hancock felt the greater the attention devoted to human relations, the better result there would be for all, as it provided the link which would enable this grand old country of ours to go from strength to strength.

Mr. Hancock stressed that there must be a real attempt, at all times, to see the other man's point of view and to find a basic solution to a problem, as this was necessary if this country was to prosper.

He believed that The Institution of Production Engineers, although a technical Institution, was making its contribution to industrial life in providing the opportunity for this subject to be discussed once a year, and he was indeed proud that this Paper should bear his name.

The **Chairman** thanked Mr. Hancock very much for those remarks, which were precisely what they had expected from him, and invited Mr. Nash to propose a vote of thanks to Mr. Banks.

Mr. S. G. E. Nash (*South Western Regional Chairman*) said it gave him great pleasure to propose a vote of thanks to Mr. Banks for the remarkable review of the subject of human relations in industry which he had given in his 1959 E. W. Hancock Paper. It added to the pleasure of everyone that on this occasion Mr. E. W. Hancock had been present to hear the Paper. He expressed those thanks on behalf of the Institution generally and particularly on behalf of the South Western Region. The members of the Institution in the Region were very proud to have had the privilege of hearing the first E. W. Hancock Paper to be presented out of London, and were grateful to the Council for the opportunity of doing so.

In the last week or so — in the Parliamentary election campaign — they had all heard different aspects of human relationships, often meretricious ones, presented to them. In Bristol there had also been a light-hearted comedy film on the subject entitled "I'm all right, Jack". In contrast, the aspect of the present Paper which appealed to him most was the underlying intention of management, which might be expressed as: "*We* will see that *you're* all right, Jack". After Mr. Banks' exposition it was obvious that this basic intention could not be left to itself but had to be engineered, and engineered on a production basis.

There was one opposite anecdote — it was really one of Mr. Fletcher's, but Mr. Fletcher had been too modest to relate it — which showed how not to do it. There was a Hungarian writer who said: "The English have no need for human relations; they have hot water bottles". It would be quite the wrong approach to say: "The English have no need for personal relations; they have personnel management". Mr. Banks had made that clear. They were all very grateful to him for his Paper.

The vote of thanks was carried by acclamation, and Mr. Banks, in reply, said it had been most fascinating to hear the questions put to him and he only wished that he was better at answering them.

The meeting then ended.

COMMUNICATIONS

Written discussion on Papers appearing in the Journal is invited for publication. Contributions should be addressed to:

THE EDITOR,

THE PRODUCTION ENGINEER,

10 CHESTERFIELD STREET, MAYFAIR, LONDON, W.1.

COPY TURNING LATHES

A review by I. B. KING, G.I.Mech.E., Grad.I.Prod.E.

Assistant Education and Technical Officer,
Institution of Production Engineers.

This Paper is divided broadly into three parts: the first describing, in general terms, the basic principles used in copy turning systems; the second dealing in more detail with machines which are in current production, particularly those designed specifically for copy turning purposes; and the third presenting practical examples of how these types of machines have been used to advantage.

Part I appears in this Journal. Parts II and III will appear in subsequent issues.

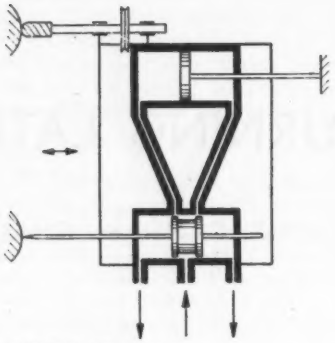
SIMPLE means of copying have been known for many centuries and have been particularly developed in the field of sculpture.

With the introduction of machine tools the idea of producing many identical components from a master was further developed. In the "Economy of Manufacture" published in 1832, Charles Babbage describes various methods of copying and of particular interest is his description of a machine for making dies:

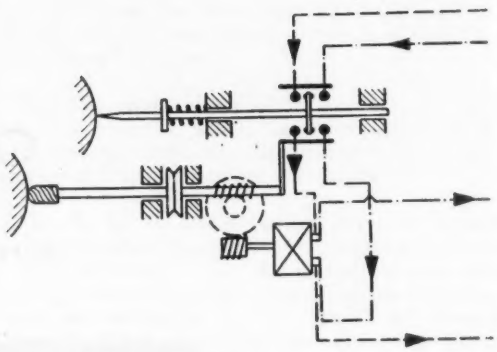
> "A lathe has long been known in France, and has recently been used at the English Mint, for copying dies. A blunt point is carried by a very slow spiral movement successively over every part of the die to be copied, and is pressed by a weight into all the cavities, while a cutting point connected with it by the machine traverses the face of a piece of soft steel in which it cuts the device of the original die on the same or on a diminished scale . . . . But the chief use to be expected from this lathe is to prepare all the coarser parts, and leave only the finer and more expressive lines for the skill and genius of the artist."

In many instances copy turning lathes are used for similar reasons today, except that the artist is replaced by a precision machine tool.

The disadvantage of this early lathe was that the stylus was kept in contact with the master by a fairly large force, i.e., a weight; hence only strong and robust patterns could be used. This disadvantage was overcome in a design registered in 1900 by the Italian inventor, Bontempi. He designed both a hydraulic and an electrical method of copying which was to be used for the copying of sculptural pieces. Figs. 1 and 2 show both systems and it will be seen that the hydraulic system is used today on many machines, while the electrical system has undergone consider-



(Courtesy of V.D.F., Germany)
Fig. 1.



(Courtesy of V.D.F., Germany)
Fig. 2.

able development. The original conception, however, still remains recognisable.

These devices had the great advantage of very low tracer pressure, which allowed quite soft masters to be used.

The equipment available in 1900 to produce such systems was not sufficiently good for the copying devices to be utilised to their full capabilities, and the accuracy of reproduction was not sufficient for many engineering purposes.

In 1923 the electrical system designed by Bontempi was further developed and patented as the "Keller" control.

By 1930 several hydraulic two-dimensional systems had been built and were installed mainly on machines in Germany and Switzerland, for reproducing turbine blades. At the same time an American lathe, very similar to that produced today, was on the market.

Developments during the period 1939 - 45 and particular studies after the War have led to the introduction of a large number of systems and machines, ranging from quite cheap but effective attachments, to complete automatic or semi-automatic machines specially built for copy turning purposes (Fig. 3 (a) and (b)).

why copy turning ?

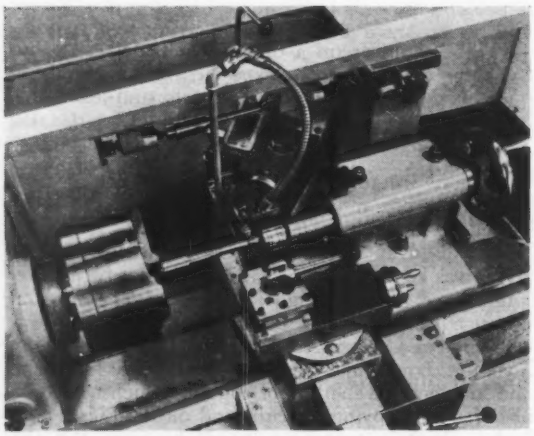
Copy turning machines are capable of producing complicated shapes very easily, either from an existing piece part or, in many cases, from a flat or round template.

The tolerances that can be held will naturally depend on the type of unit used, but can be as low as ±.0002 in. on diameters and ±.001 in. on lengths.

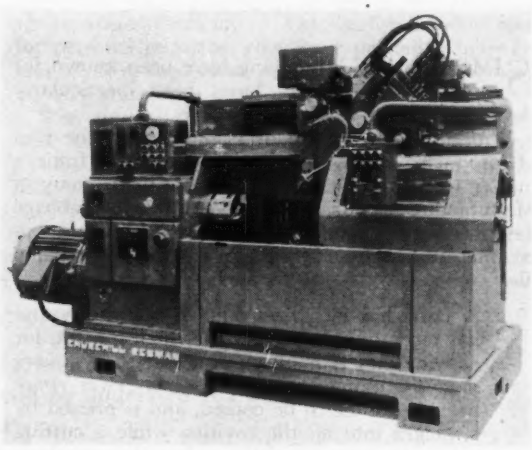
Obviously, economy is the overriding factor but considerable savings can be made over existing methods, particularly where complicated tool set ups have been required.

This greater freedom from tooling complications gives the designer the added advantage of being able to design what is really required to achieve the specification, rather than effect a compromise with the production engineer.

Measuring can also be reduced, since once one diameter is found to be correct, then the others will



(Courtesy of Willson Lathes Ltd.)
Fig. 3(A).



(Courtesy of Churchill-Redman Ltd.)
Fig. 3(B).

also be correct. Allowances may have to be made for such factors as tool wear which will affect dimensions, particularly those which have to be held to close tolerances, and in addition the natural variability of the machine will affect the finished dimensions.

It should be made quite clear at this stage that the use of a copy turning system on a lathe, whether it be an attachment or a specially designed machine tool, will always produce parts which have a wider tolerance range than those produced by the basic machine tool without a copying system.

The purpose of this Paper is to outline briefly the available systems with their advantages and limitations, describe a typical range of machines, and illustrate by case studies where copying lathes have been used to advantage.

servo-controls

Methods of copying may be broadly classified into two main divisions :-

(i) in which the tool slide is moved directly by a template;
(ii) in which the tool is actuated by a servo-mechanism.

Further details on the first type are given later and whilst the object of this Paper is to describe machines which employ servo-control, those described in (i) have a field of activity which probably could not be bettered.

A servo-mechanism can be defined as a self-correcting device and has to fulfil three conditions. It must :

(i) be completely automatic;
(ii) be error-actuated;
(iii) consist of a closed loop.

The closed loop is necessary to check that the position of the output (i.e., the tool) is where the input information has called for it to be; if it is not, then the two positions will be compared with one another and the error between the two used to actuate the device in such a way that the error is reduced towards zero.

This concept can be represented by means of a block diagram.

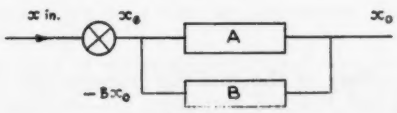


Fig. 3.

In most cases there is a need for power amplification so that the error signal x_e is fed to an amplifier and output device A. The output position x_o is fed back to the input in some manner, e.g., mechanical, electrical or hydraulic means, and compared with the input. Whatever method is used it will produce some modification of the signal, either in amplitude or time relationship (this is known as phase change), hence the presence of the block B.

The value of B is the relationship between the input and the output signal in the feed back link. This is the transfer function of the feedback link and is normally frequency-dependent. The feedback is so arranged that the signal is subtracted (negative feedback) from the input signal to produce an error signal.

In relating this to a copy turning lathe, in many cases the input information is in the form of a template which controls the position of a stylus which regulates a motor controlling the position of the tool. The feedback link is normally mechanical in that the stylus and tool are mounted on the same slide.

With reference to Fig. 3 :

$$x_e = x_{in} - Bx_o \qquad \text{.....(i)}$$

$$x_o = Ax_e \qquad \text{.....(ii)}$$

hence $x_e = \dfrac{x_o}{A}$

From (i) $\dfrac{x_o}{A} = x_{in} - Bx_o$

$$\left(\frac{1}{A} + B\right) x_o = x_{in}$$

$$\frac{x_o}{x_{in}} = \frac{A}{1 + AB} \qquad \text{.....(iii)}$$

This equation relates the input and output position with the gain of the amplifier and feedback link.

If A is very large then

$$\frac{x_o}{x_{in}} = \frac{1}{B} \qquad \text{.....(iv)}$$

This equation shows that the position of the output compared to the input is independent of the changes in amplification of A caused by changes, for instance, either in hydraulic pressure or electrical voltages.

This presupposes that the feedback link is passive, i.e., not affected by similar disturbances, and this is achieved in a mechanical link.

In practice all amplifiers are frequency-conscious and the gain A will only be large over a limited frequency range.

The above equations have assumed that the system is linear; this is not necessary for the functioning of a servo-mechanism but it makes the analysis very much simpler.

If a step function input is applied, this is met approximately when the tracer meets a shoulder, and this corresponds to an infinite slope step which demands an infinite band width in the amplifier for perfect following, i.e., it will respond to a signal of any frequency.

From equation (iv) for perfect following it requires $B = 1$, and the error x_e will be zero.

$$x_e = x_{in} - x_o$$

but $x_o = Ax_e$

$$x_e = x_{in} - Ax_e$$

$$x_e = \frac{x_{in}}{1 + A} \qquad \text{.....(v)}$$

This shows that the ability to follow a step function does depend on the frequency response and gain of the amplifier A. The greater the value of A the smaller the error.

So far only position has been considered and the fact that such a system is dependent on the frequency of the input signal for accuracy in following.

Assuming that the output velocity is proportional to the input error (i.e., the system in linear) :

$$\frac{dx_o}{dt} \propto x_e$$

i.e., $$\frac{dx_o}{dt} = kx_e$$

From ii

$$\frac{dx_o}{dt} = \frac{kx_o}{A}$$

Assume that A is constant with respect to time

$$\frac{dx_o}{x_o} = \frac{k\,dt}{A}$$

Integrating

$$\log x_o = \frac{kt}{A} + \text{constant}$$

$$\therefore x_o = e^{\frac{kt}{A}} + \text{constant}$$

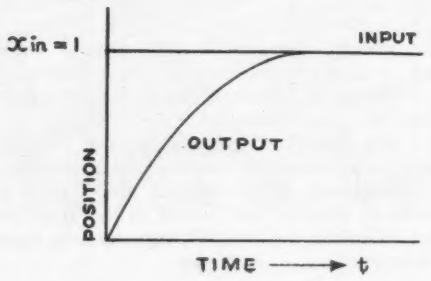
When A is very large $e^{\frac{kt}{A}} \rightarrow e^{\circ} = 1$

$$\therefore \text{constant} = x_o - 1 = \frac{x_n}{B} - 1$$

$$\therefore x_o = e^{\frac{kt}{A}} + \frac{x_{in}}{B} - 1$$

If $B = 1$ and x_{in} is made equal to 1, then

$$x_o = e^{\frac{kt}{A}}$$



By plotting this output position against time, the curve will be as shewn.

This simple analysis shows that a servo system requires a high gain in the "active" elements, and that it will not follow immediately any sudden change in input.

Considering now a physical system, e.g., a copy turning lathe in which an error signal is applied which regulates a motor driving the tool slide (the term motor is used to describe a ram which gives linear motion or a hydraulic motor to produce rotary motion.

In a system in which a ram is used, the force applied by the ram is used in two ways :

(i) in overcoming the load, both tool load and friction;
(ii) in accelerating the ram and tool slide to its new position.

As the error decreases the force on the ram will also decrease and the acceleration will fall to zero. The velocity, however, may still be a finite quantity and the slide will only come to rest under the action of the tool thrust, and the friction of the tool slide. If these forces are small compared with the inertia, then the load will over-shoot the final position and an error signal will be produced such as to cause the slide to move in the opposite direction in an attempt to make the error zero. This cycle is then repeated and oscillations will be set up, the degree of oscillation depending on the resisting forces, i.e., damping.

The effect of damping is shown graphically for a step function input. (Fig. 4.)

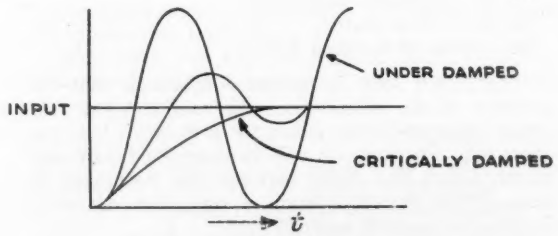


Fig. 4.

The effect of the stick-slip phenomenon is well-known and this will also affect the accuracy of the system, in that a finite value of stylus movement is necessary before the slide will move.

It is possible to devise a system which is not only position-conscious, but also conscious of velocity and acceleration. Additional feedback links are required for this. Since, however, the majority of servo systems used on copying lathes are over-damped, oscillation is unlikely to occur.

copying accuracy

It is possible to show graphically the effect of these factors on the turned surface of a component (Fig. 5).

Let *AA* be the outline of the template; to compare the toolpath *B* with that of the template the toolpath is superimposed. The stylus and tool slide are normal to the lathe axis.

When the stylus meets the template, it does not immediately initiate a movement of the tool slide. A further longitudinal movement is necessary so that the stylus is deflected by a distance r_s, for the reason mentioned above, or due to either manufacturing tolerances or the design of stylus used, or possibly a combination of all three.

A time delay occurs before the slide will begin to move, and the movement of the tool point will be the resultant of the slide feed and the longitudinal feed, i.e., it will move along the path 2, 3. At point 3 the stylus will re-enter the tolerance range and the tool slide will, after a suitable time interval, begin to decelerate until it stops at point 4. Movement will then be parallel to the axis of the lathe. The position of point 4 will be determined by the forces applied to stop the slide. If it should fall outside the tolerance range, then an impulse will be produced which will move the ram back towards the line of the template. In Fig. 5, point 4 is within the tolerance range.

Thus, in following a slope a part will be produced with a surface configuration of height *h*.

It should be noted that a mean velocity has been assumed for the cross slide; acceleration and decelerations will make the path rounded.

For any particular angle of template and time constants in the system, the value of *h* will depend on the magnitude of *f*, the longitudinal feed and the tool slide velocity *V*.

i.e., if $\frac{V}{f} > \tan \alpha$ then the tool will follow the template,

if $\frac{V}{f} < \tan \alpha$ then the tool can no longer follow the template.

Where α = angle between template and the longitudinal axis of the lathe.

Hence if the tool slide velocity is known the maximum value of *f* can be determined for any particular slope.

If the slope of the template is steep, with the tool slide set perpendicular to the lathe axis, the tool will not be able to follow the required path; however, by setting the tool slide over at an angle it is possible to cut steep slopes and by setting the slide at above a certain minimum value square shoulders are possible (Fig. 6). In some cases even a slight undercut can be obtained.

If, for example, β is 45° and constant feed is used, then the limiting shapes that could be copied would be somewhat similar to that of Fig. 7.

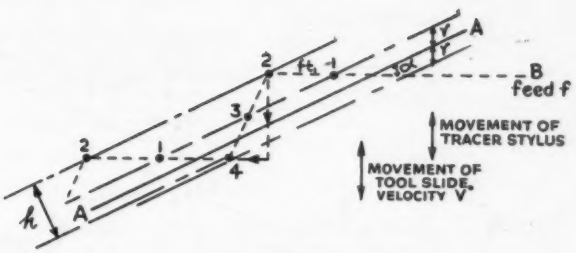


Fig. 5.

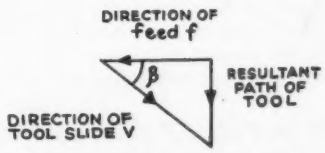


Fig. 6.

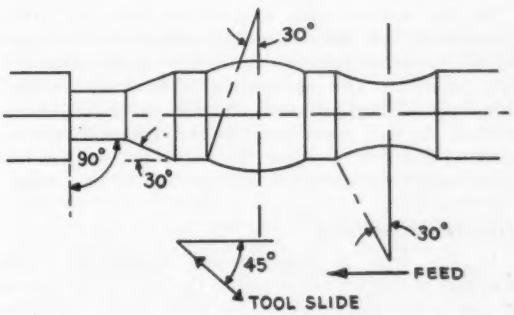


Fig. 7.

slide at an angle to lathe axis

The surface configuration when the tool is set at an angle will be as in Fig. 8. When the stylus reaches point 1, a signal will be transmitted for the slide to move in direction *Y*; after a time interval *t*, the slide will begin to move and the tool point will move in the direction produced by the combination of feed and tool slide movement; at 3 the stylus enters the tolerance range and the signal is cut off, but the slide will carry on for a period t_s before the signal is received at the slide and the slide stops. However, when the stylus reaches 4 a signal is again produced, only this time to move the slide in the direction *X*; once again it takes time before the slide will begin to move, t_s; normally $t_t = t_s$, or very nearly so.

The path 6, 7, 8, and 9 will once again be determined by the combination of feed and tool slide velocity.

It is assumed that the tool slide velocity is the same in both directions. The value of *r* is measured in a direction parallel to the stylus movement.

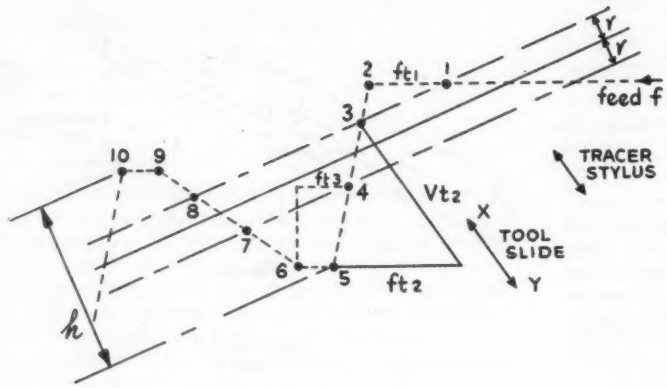


Fig. 8.

From the brief analysis above, it will be seen that the height of the surface configuration h is dependent on the slope of the template, angle of stylus and tool slide, system time constants t_1 *and* t_2, velocity of slide and feed. A simple trigonometrical analysis will give an expression for h.

So far systems with a constant feed have been considered, but these have limitations in the shapes which can be cut, particularly where square shoulders are required. The alternative is to have variable longitudinal feed, or one capable of being disconnected. As was mentioned earlier, the criterion for altering the feed is when the movement of the tool is no longer directed towards the line to be copied.

discontinuous feed

If the feed is disconnected completely, then if square shoulders are required the tool slide must be set perpendicular to the lathe axis; when, however, a system of varying the longitudinal feed is used, it can be set over at an angle. Fig. 9 shows the tool path for a machine with a discontinuous feed.

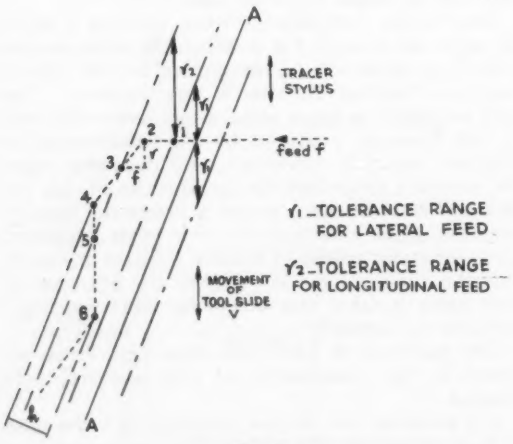

TRACER STYLUS
feed f
Y1 –TOLERANCE RANGE FOR LATERAL FEED
Y2 –TOLERANCE RANGE FOR LONGITUDINAL FEED
MOVEMENT OF TOOL SLIDE V

Fig. 9.

As before, the tool path 2, 3, and 4, is determined by the combination of feed and slide velocity; at 3 a signal is produced to stop the feed, which takes place at point 4, and the tool moves along 4, 5 and 6; at 5 the signal to re-engage the feed is produced and this will then recommence at 6 and the cycle will repeat itself. It will be seen that the longitudinal feed is controlled by a second tolerance range r_2.

Naturally the surface configuration will depend on the system variables and the stylus may re-enter the tolerance range r_1; depending on the system constants, the surface will vary accordingly.

If r_2 is very small the longitudinal feed can be controlled, even though it would be possible to copy with the feed held constant.

If the minimum height of the surface configurations produced by the various systems is calculated, it will be found that the system which controls both longitudinal and transverse motions exhibits an inherently better copying accuracy than if only one movement is controlled.

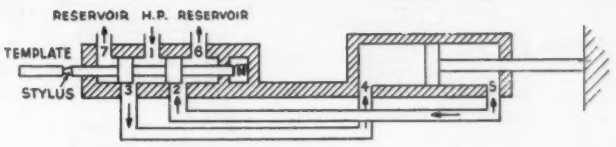
methods of tool actuation

Methods of moving the tool slide are numerous and are mainly as follows :-

1. mechanical linkages
2. electric motors
3. hydraulic motors (a) linear; (b) rotary.

The first type have limited application and in the type in which the tool slide is kept in contact with a template, only gradual changes in profile can be accommodated. Other types of machines use cams to produce the required profile, and for small parts the Swiss type automatic is a good example. For larger items special fine turning lathes are available and by taking small cuts, higher accuracies can be achieved. With this type of equipment the full tool forces are transmitted back to the template, which must be extremely rigidly mounted and capable of withstanding wear, if a high degree of accuracy is to be maintained.

Fig. 10.



The tool slide actuator must be controlled so that the required path is followed and various methods can be used to present the required information to the machine :

1. template, either flat or round, traced by a stylus;
2. drawing — scanned photo-electrically;
3. numerical information — either in the form of punched cards or tape or magnetic tape.

The first method is the most popular, in that templates are relatively simple and cheap to make or an existing part can be used. Tolerance on diameters of the order of ±.0002 in. can be produced if necessary.

Method 2 could be used for parts having wide tolerances; so far it has not been used on copy turning lathes, but it has been developed for other types of machining processes.

Method 3 has so far been used only on experimental copy turning machines. Many systems have been developed for milling and boring machines and no doubt these methods will be used in the future on lathes.

In a template controlled lathe, the template is scanned by a stylus which regulates in some way power to the driving mechanism.

Possible combinations of stylus and motors which are used are :-

1. all-hydraulic;
2. all-electrical;
3. pneumatic-hydraulic;
4. electro-hydraulic;

hydraulic systems

1. template controlled

The stylus is connected to a valve which meters high pressure oil to either a ram or hydraulic motor (possibly a combination of both, e.g., ram operated tool slide with the longitudinal feed driven by a hydraulic motor).

Feedback is achieved by mounting the tool with stylus and valve (i.e., the tracer) on the same cross slide, thus forming a mechanical feedback link between the two.

As has been previously described, for the servo-mechanism to follow very rapidly changes in input it must have a high natural frequency which infers that acceleration of the tool must be high, if the input changes demand it; hence the ratio of applied force to total inertia plus friction must be large. This can be easily achieved with a hydraulic system, with the additional advantage that low speeds can be obtained without intermediate gearing. In fact, full force can be achieved at zero velocity.

With a system driven by electric motors, some form of intermediate gearing is necessary to give low speeds and the maximum acceleration of such a system will be when the inertia of the load, referred to the motor, is equal to the inertia of the motor. Since in some cases large motors will be required, this will then be a limiting factor in obtaining high accelerations.

An additional factor in favour of the hydraulic system for high accuracy work is that high retardation of the slides can be achieved by blocking of the exhaust ports of the ram or motor.

System I

This system has been used very successfully on a large number of machines for moving the cross slide and is simple and reliable. (Fig. 10.)

Fig. 10 traces out the flow of oil; the tool slide has been omitted for clarity.

High pressure oil is supplied from a pump to port 1 of the spool valve; if the stylus is not touching the template the spool is deflected by the spring to the left, port 3 will open and the high pressure oil will pass into the cylinder at 4 and the tool slide will, with the body of the tracer, move to the left. Exhaust oil will pass from the cylinder via ports 5, 2 and 6.

In order to adjust the size of the finished component, either the position of the tracer is adjustable or the toolbox is carried on a separate slide.

When the stylus meets the template, the spool is deflected to the right and oil under pressure will be admitted to the cylinder via ports 2 and 5. The cylinder will move to the right until the valve once again closes, exhaust oil passing through ports 4, 3 and 7.

In some designs the cylinder is fixed and the piston connected to the slide.

For the system to respond to small movements of the stylus the spool must be made to extremely small limits, and the width of the spool shoulders should be equal to the width of the port. The relationship between the size of the shoulder and the size of the port is known as lap, and in most systems zero lap or slight underlap is used. The design of spool valves is covered in greater detail in a later section.

The oil demand of such a system varies from zero to a maximum value depending on the spool deflection. To cope with this variable demand, either a constant pressure pump is used, of sufficient capacity to meet peak demand without an excessive

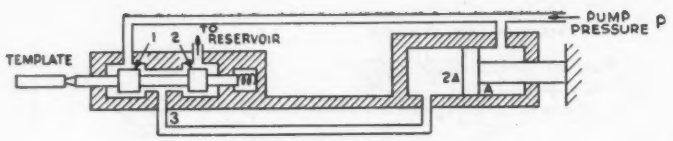


Fig. 11.

fall in pressure, and fitted with a blow-off valve; or a smaller pump and a hydraulic accumulator are fitted (the accumulator beng fitted with pressure relief valves). If the former is used care must be taken to see that there is not an excessive rise in oil temperature nor air entrapped in the oil. The presence of air increases the compressibility with consequent loss of accuracy.

System II (a)

To overcome these difficulties of

(a) having to manufacture a highly accurate valve;

(b) large variations in oil consumption,

systems have been developed which act as a hydraulic potentiometer. (Fig. 11.)

Here the pump supplies oil to the valve and in the position shewn oil flows back to the reservoir through openings 1 and 2. If the position of the valve is such that the pressure drop across each opening are equal then the pressure at 3 will be $\frac{P}{2}$.

By making the areas of the piston A and 2A as shown, the forces applied to both sides of the piston will be equal and no movement will take place.

If now, under the action of the template, the spool moves to the right then the pressure drop across 1 will increase and the pressure at 3 fall below $\frac{P}{2}$. The forces on the piston will be unbalanced, and the cylinder will move to the right until the opening at 1 is sufficient to produce equilibrium again.

When the spool moves to the left the pressure at 3 rises above $\frac{P}{2}$ and the cylinder moves to the left until equilibrium is reached.

The main disadvantage of this method over System I is that the effective force can never be greater than $\frac{P \times A}{2}$ hence for a given force a larger piston is necessary than in System I.

System II (b)

There are various modifications to this system, particularly in the valve arrangement; but, basically, high pressure oil is pumped to the piston rod side of the piston, where an orifice drilled through the piston will allow oil to pass through to the other side and then back to the reservoir via the template-controlled valve. (Fig. 12.)

The pressure P_1 will depend on the pressure drop across the valve; this valve will be in an open position at equilibrium because of the differential area of the piston. Under the action of the template the valve will tend to close, P_1 will approach pump pressure P and the cylinder and valve body will move to the right until equilibrium is once again achieved.

With the valve open wide under the action of the spring, the thrust will be such that the cylinder and valve are fed towards the template.

As in the case of System II(a), there is normally a continuous flow of oil through the system.

System III (a) and (b)

In this system the cross slide is placed perpendicular to the lathe axis and the tracer head is so designed that with a small deflection of the stylus, only the cross slide moves. When a shoulder or a steep slope is met, the stylus deflection is increased and a point is reached when movement of the cross slide is unable to follow the slope. To overcome this, the tracer is so designed that at the point where the cross slide movement is unable to follow the profile, the feed is either reduced or disengaged.

In a hydraulic system two alternative methods of controlling the feed suggest themselves:-

(a) if the longitudinal feed is produced by a ram or a hydraulic motor driving a feed shaft, then the speed of either driving unit can be made proportional to the valve opening. The valve can be so designed that for large stylus deflections the oil flow is cut off and the feed will stop.

This does, however, have the disadvantage that the valve must be capable of passing large quantities of oil.

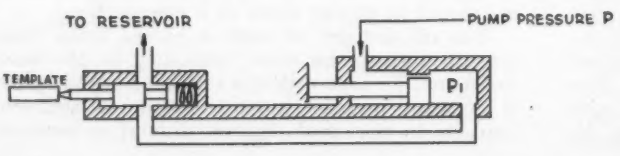


Fig. 12.

(b) Alternatively, the feed shaft can be driven at constant speed being connected to the motor through a hydraulic operated clutch and brake system. This, however, will only give an on-off control.

System IV

By pumping oil through a movable nozzle, oil can be directed to either side of the piston; the nozzle being connected to the stylus (Fig. 13).

Depending on the forces required, the nozzle can either direct oil straight to the cylinder or act as a pilot valve for moving a main valve of the spool type.

The principle of this device is the conversion of pressure through the nozzle into kinetic energy; this is then reconverted into pressure energy in the tapering passages of the orifice block.

In some forms the high pressure oil is introduced through the pivot and the "noise" effect of the oil flow produces a slight vibration of the nozzle which reduces friction at the pivot. Friction can be reduced to an even lower level by having a fixed and a movable nozzle (Fig. 14).

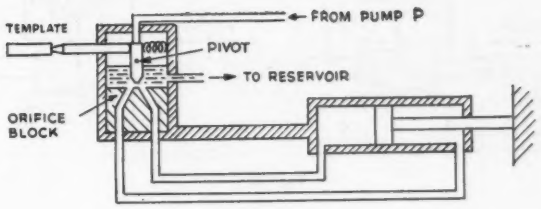


Fig. 13.

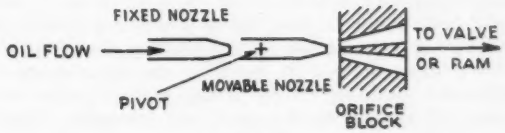


Fig. 14.

hydraulic valves

The preceding descriptions of the main types of purely hydraulic copying systems underlines the fact that the most important element in the system is the valve controlling the flow of oil to either side of the piston. In the majority of cases this is of the spool type, and the following section is devoted to amplifying the characteristics of such a valve.

The valve used in System I (Fig. 15 (a) and (b)) is taken as an example.

The pump pressure is applied at *P* and this is switched to either side of the piston by movements of the valve spool.

In order that the spool may follow changes of contour of the template, and that the contact pressure be as low as possible, it should have the least possible friction. However, with either type of valve the oil pressure on the spool will cause a side thrust which will increase the friction, unless the ports are in some manner opposed so that the thrusts are balanced out. An alternative is for an annulus to be cut at each port (Fig. 16) so that the spool is balanced; this also has the effect of balancing the leakage forces.

The amount of leakage will depend on such factors as the degree of overlap or underlap clearance between the spool and sleeve, oil viscosity, etc.

If there is a tendency for the leakage forces to give rise to any unbalance, then a series of grooves can be cut in the spool or sleeve which will tend to re-balance the pressure distribution. This can only be done where there is considerable spool travel.

Where the travel is small, side thrust due to leakage can be mitigated by making the spool slightly tapered; it is important, however, that the taper be in the right direction. (Fig. 17.)

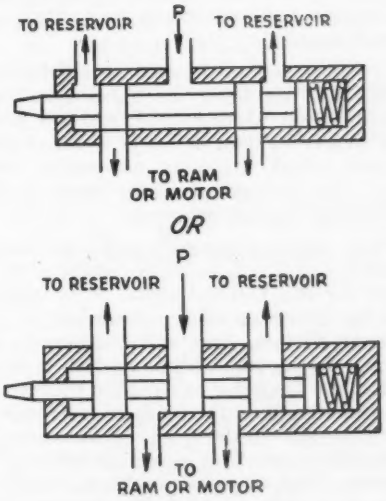


Fig. 15(A) — Upper.
Fig. 15(B) — Lower.

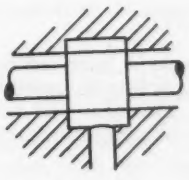


Fig. 16.

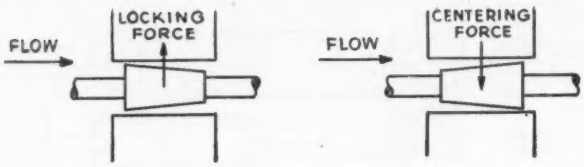


Fig. 17.

If taper is used there is a tendency for small dirt particles in the oil, or produced by wear in the valve, to become trapped in the tapered gap. At first only large particles will be collected and these in turn will trap smaller ones; the action being similar to that of a filter. It has been suggested that particles down to 4 microns in diameter can be trapped in this way. Build-up of this wedge will of course take time. Movement of the spool will normally destroy it and the particles will be swept away by the flow. However, there is a possibility of jamming and this illustrates the necessity of adequate filtering of the hydraulic fluid by ensuring that the spool is continually on the move, either by giving it rotary movement or by a high frequency, low amplitude, axial movement. Static friction and silting up may then be overcome.

Rotary movement of the spool is the ideal method, since this will not affect the input signal which is axial in direction. Mechanically, however, it is more difficult to achieve than the latter. With an electrical transducer a high frequency movement, known as "dither," can be applied to the spool which does not affect the copying accuracy.

Machine tools are naturally prone to vibration in themselves, and this is normally sufficient to obviate the need for this external signal to be applied.

Even by taking as many precautions as possible to minimise friction, there will undoubtedly remain some force due to static friction which is of greater value than the force due to dynamic friction. Hence, until a force sufficiently large to overcome static friction is applied to the spool, no movement of the tool slide can occur. This minimum force will result in a narrow band of stylus movement which can be called a dead zone, and which, although small in itself, could conceivably include quite a large proportion of the total axial movement of the spool. Hence the response to the input signals may be unsatisfactory.

In the design in which there is a continuous flow of oil, this dead zone may not be so wide, since the flow of oil will result in disturbances which tend to cause dither.

It will be seen in a later section that the spool can be operated electrically, possibly using a stylus-operated switch. This also will have a dead zone, since there must of necessity be clearance between the contacts.

On large machines where the output power of the copying system is high, a considerable flow of oil through the valve may be required, and this will give rise to the so-called "Bernoulli" forces, which tend to bring the spool back to its central position when the port is opened by a small displacement of the spool.

If the flow of oil through the port is Q, cubic in./sec. and P is the total pressure drop in the valve, equally divided between inlet and outlet orifice; then the restoring force F is $F = .0064\ Q\sqrt{P}$ lb. (Fig. 18.)

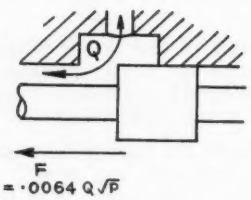


Fig. 18.

This expression can be plotted graphically, for various values of pressure drop and it can be seen that large forces can be produced. (Fig. 19.)

These forces for a directly operated spool, and particularly if the pressure in the system is high, will tend to broaden the dead zone and limit the

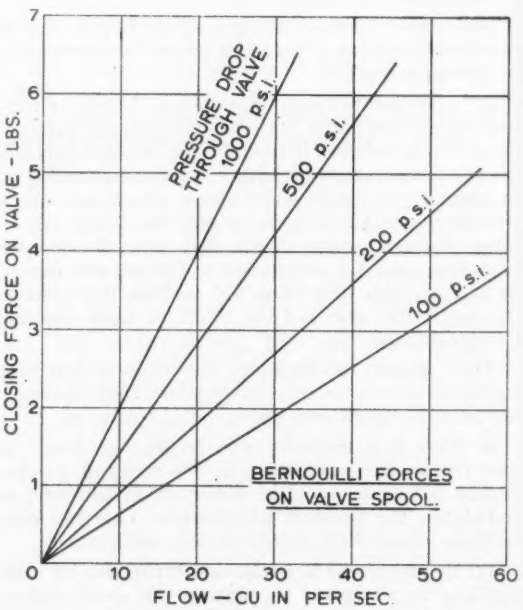


Fig. 19.

accuracy of the system as well as increase the pressure on the template. This increase in load on the template may be of importance if fragile templates have to be used, e.g., if a long slender shaft is used as a master component.

With the stylus connected directly to the spool, the valve must be sensitive to movements of the order of .0001 in. to achieve accuracy of tool movement. With such small openings fluid friction is likely to be apparent and can be measured relatively easily.

effect of fluid friction

An experimental method for measuring the effect of friction is for the discharge to be measured from a pipe, the discharge being varied by means of a movable tapered plug in the open end (Fig. 20).

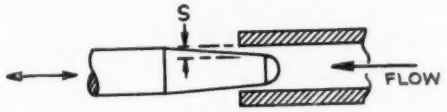


Fig. 20.

The size of the annulus S is then controlled by the position of the plug.

If the theoretical maximum flow is plotted against the size of the annulus S, together with the experimental flow, a comparison between the two can be made (Fig. 21). In both cases the head of fluid must be the same.

In a valve design in which there is a continuous flow of oil (Systems II (a) and (b)), this problem is overcome by ensuring that the orifice is sufficiently large, as determined by point X where the slopes of the two curves are equal. Then the changes in flow for small changes in annulus size are identical.

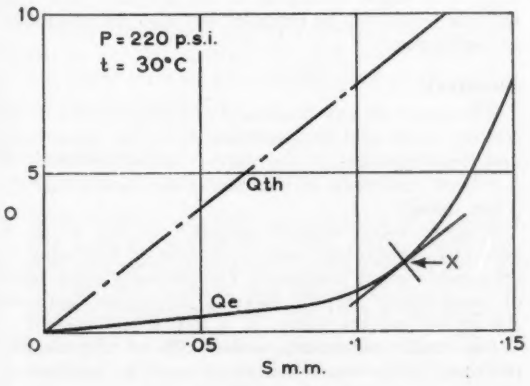


Fig. 21.

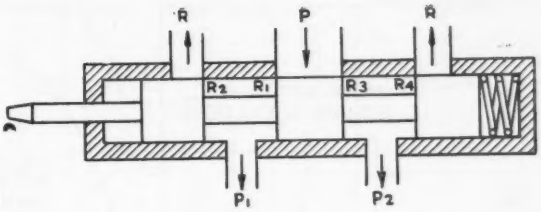


Fig. 22.

It should be remembered, however, that although by having a continuous flow an improvement in response is obtained, the pressure differential across the piston is not so great as in System I, which will tend to offset the improvement; hence, for a given force a larger piston area will be required.

Having a continuous flow also tends to reduce the stiffness of the system; stiffness can be loosely defined as the ability of the "motor" to obtain and retain the desired position against the action of externally applied loads. With valves of a type used in System I, when the spool is in the neutral position the flow out of the cylinder or motor will only be leakage around the shoulders of the spool.

Normally roughing and finishing cuts will be taken which will overcome difficulties associated with reduced stiffness.

If the leakage resistances across the port and spool shoulder are as indicated in Fig. 22, then the four hydraulic resistances form a hydraulic Whetstone bridge.

In balance $\frac{R_1}{R_2} = \frac{R_4}{R_3}$ hence by making $R_1 = R_4$ and $R_2 = R_3$ the bridge will balance. (Fig. 23.)

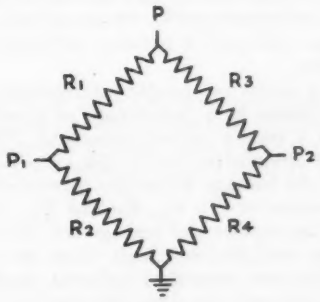


Fig. 23.

Then $P_1 - P_2 = P\left(\frac{R_2 - R_1}{R_2 + R_1}\right)$ (This is determined in the same manner as for an electrical network using Kirchoffs Laws.)

If a small deflection occurs then R_1 or R_2 will become very large, and the bracketed term will approach unity and the pressure difference $P_1 - P_2$ will be almost equal to the pump pressure P.

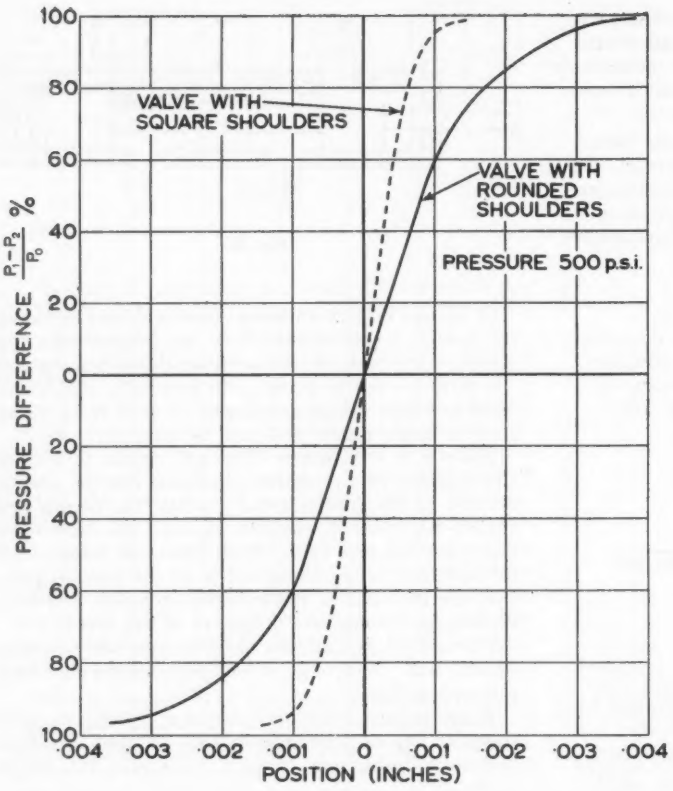


Fig. 24.

Graphs of pressure difference against valve movement can be plotted and with $P = 500$ lb./sq. in and using a valve with square shoulders on the spool and ports, reference to Fig. 24 shows that movement of .0001 in. will give a pressure difference of some 75 lb./sq. in.

Fig. 24 is a curve of pressure differential across the valve, expressed as a percentage of input pressure, plotted to a base of valve movement. The slope of the almost straight portion of this curve will depend largely on the leakage across the corners of the spool, i.e., the values of R_1, R_2, R_3 and R_4. Where the shoulders are square the leakage will be reduced to a minimum and the slope high; if on the other hand the shoulders are tapered or radiused, then the sensitivity will fall and the slope will not be so steep.

As mentioned above, a movement of .0001 in. can produce a pressure difference of 75 lb./sq. in. As we have seen earlier, for such small openings flow is severely restricted due to fluid friction, but even so may be sufficient for a small cylinder.

A typical flow curve for a high sensitivity spool valve is shown in Fig. 25.

Full flow of oil is achieved by a very small movement of the valve; valves with such high sensitivity act more as a switch than as a proportional device. Under these conditions small movements will allow full flow of oil, which will cause the tool to have a high acceleration towards the neutral point; this movement closes the valve, but the slide will continue to move under its own inertia, causing the valve to open in the opposite direction and the cycle will be repeated, i.e., oscillation will occur. These oscillations will be damped out by frictional forces, but it may be necessary to apply some form of artificial damping if the inherent damping is insufficient. This could be achieved by modifying the shoulders of the spool, e.g., by a slight rounding of the corners. Not only will the sensitivity be reduced, but also the possibility of oscillations.

summary

The heart of any hydraulic copying system is the control valve, and to appreciate fully the advantages and disadvantages of the various types marketed, it has been necessary to consider their functioning in some detail.

A spool valve, directly actuated by the stylus, is perfectly satisfactory and is capable of following to reasonably small tolerances. Occasionally some form of mechanical amplification is interposed between the stylus and the valve. It is also a stiff system.

For small movements either side of the neutral position, the pressure difference may be insufficient to cause tool slide movement, i.e., there is a dead zone.

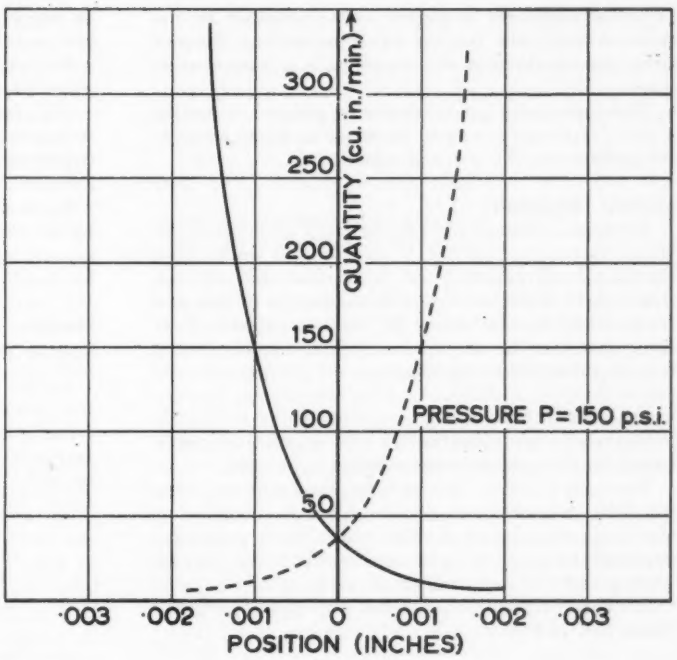


Fig. 25.

Systems with high sensitivity may, if not properly damped, tend to oscillate.

The necessary pressure difference across the piston may be produced by modifying the hydraulic circuit so that the valve throttles a continuous flow of oil. For any given thrust, a larger piston area will be required than for the first type, i.e., System I.

On large machines where there must be a considerable flow of oil, due to the large cylinder used, valves of large diameter, and with a long movement rather than a small movement, are necessary if the system is to be capable of high accuracy.

High rates of flow through the valve produce considerable restoring forces which will give rise to high stylus pressures.

It would, therefore, appear necessary that if high sensitivity or the control of large machines is required, some form of pre-amplification of the stylus movement is necessary.

pre-amplification

Various methods are available, e.g. :

Mechanical — normally in the form of an arm ; this is only possible for small ratios, otherwise to ensure sufficient rigidity the arm would have to be relatively massive and its inertia would then become appreciable and slow down the system.

Hydraulic — by making the spool valve into a two-stage valve, i.e., a small valve operating the larger one, it is possible to have small operating forces.

The swinging jet relay has already been mentioned in System IV.

pneumatic - hydraulic

Pneumatic pre-amplification offers the advantages of a reasonably high magnification with a high speed response. The speed of response of a pneumatic system shows to advantage when it is necessary to have long pipes between tracer and ram or motor.

System V

The position of the spool will depend on the back pressure P_B and this will be controlled by the distance between the nozzle and the template, the remainder of the hydraulic system being as previously described (Fig. 26).

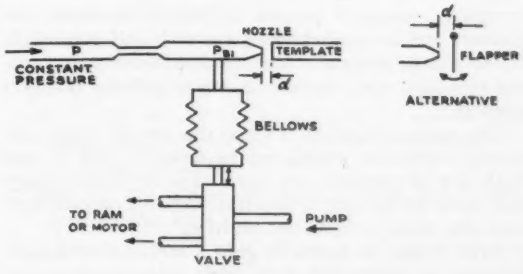


Fig. 26.

In some systems a flapper valve actuated by the stylus is used, the flapper being at such a distance from the nozzle that the response is approximately linear.

This same principle is used with a tracer actuating a spool type valve, which allows air to bleed away in proportion to the stylus displacement.

electro - hydraulic

Electrical transducers can be used to amplify the stylus movement and can be designed to work either on the on-off principle or as proportional devices. The system described below works on the former and is one which has proved to be highly successful. Very large gains can be obtained, with fast response times, by using electrical amplification.

System VI

Electronic amplification of the stylus movement, based on the original Bontempi idea, is used.

For such a system to function accurately and consistently, it is necessary for the electrical loading on the contacts to be small. This will allow a small gap between the contacts to be used and will also prevent pitting and deterioration of the contacts.

A very simplified outline of the system is illustrated in Fig. 27.

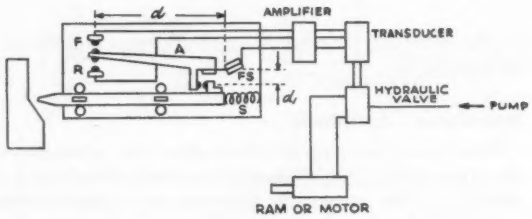


Fig. 27.

The tracer stylus is mounted between ball races for easy movement; when contact is made with the template the stylus moves inwards and allows the arm A to move across and make contact with R. This will produce a signal which is amplified electronically and fed to the transducer, which in turn opens the spool valve in the direction that moves the tracer away from the template.

If, however, the tracer is not in contact with the template, spring S presses the stylus forward and contact will be made between arm A and contact F. By so doing, the slide and stylus will move towards the template until contact is made and the contacts opened.

The neutral position is when the arm A is approximately centrally positioned between F and R and both sets of contacts are open. The hydraulic valve will then be in such a position that oil cannot flow and the slide is fixed in position.

Arm A can be made to give a mechanical amplification of about 10 : 1, so that very small movements of the stylus will cause switching to occur, and as low power at the contacts is used clearances of a few tenths of a thou. between the contacts is sufficient. Such a system can be made to respond to stylus movements of .00008 in. - .0001 in.

To accommodate such small movements the arm A must be able to move without play, and consequently a kinematic mounting is employed in the form of a flat spring F.S.

Because of the high power magnification possible by electronic means, the stylus movement can be rapidly transferred into a large movement of the hydraulic valve.

electro - mechanical

System VII

In the simplest type of electro-mechanical system the stylus has built-in contacts controlling relays which, in turn, control the current to electro-magnetic clutches. The clutches are interposed between the drive motors and the cross slide feed shaft (Fig. 28).

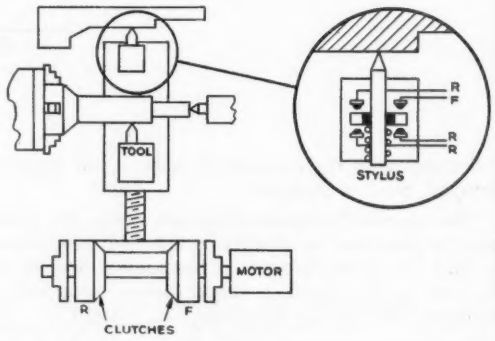


Fig. 28.

System VIII

Basically the stylus movement is detected electrically, amplified and the signal used to control the electric motors which drive the feed screws.

Many designs are such that the cross slide is normal to the lathe axis and both the longitudinal and cross feed are controlled from the stylus. The transducer can be sensitive to deflections of less than .0005 in. Various methods can be used to transform the mechanical movement of the stylus into electrical signals, e.g., changes of resistance, capacitance or inductance.

The latter is popular in that it can be made very robust, and there are no contacts used; in one well-known system the stylus, which is mounted at right-angles to the plane of the template, carries at one end an energised coil centrally placed between four other coils equally spaced around it. Upon deflection of the stylus the voltage generated in the fixed coils will be changed, in proportion to the stylus deflection. These changes are then amplified and used to control the split held generator of a Ward-Leonard

set. These, in turn, supply a variable voltage, of either polarity, to the servo motors which drive the lead screws to provide the motion in two axes.

A Ward-Leonard set is necessary to provide the power required at the drive motors, as this is too large to be accomplished by purely electronic means. This method will obviously give the system a larger time constant which will affect copying accuracy.

Since the speed of the drive motors is proportional to stylus deflection the saddle and cross slide feeds are complementary, and a constant tool feed rate will be achieved.

When the stylus meets the template, contacts RR are closed, which causes clutch R to be energised, and thereby the motor rotates the transverse feed screw in such a way as to withdraw the cross slide from the template.

hydraulic systems

It will be seen in a later section that the majority of copying lathes are fitted with a hydraulic system of operation and in consequence, it has been found that certain precautions have to be taken to ensure consistent accuracy. Any foreign matter, sludge or deposits caused by oil oxidation may cause jamming of valves or at least excessive wear, which will lead to loss of accuracy. Gummy deposits are not always caused by deterioration of the oil, but by the gradual decomposition of the rubber linings of the flexible hose which is often used, and periodic inspection of these items will help to overcome this trouble. To help overcome the effect of these deposits, adequate filters are fitted into the fluid circuit.

Use of the incorrect oil in which there is low lubricity and film strength will cause excessive wear of valves, motors and pumps. Too light or too heavy an oil will affect the working of the system and the effect of temperature on the oil must also be considered, as if it is too heavy it will affect the warming-up period. In order to keep the temperature of the oil, under operating conditions, as near constant as possible, a large reservoir is used.

There are two basic methods of controlling the flow of oil in a hydraulic system:

(a) the constant volume system ; and
(b) the variable volume system.

In (a) a constant speed pump discharges a constant volume at a constant pressure, the flow of oil being controlled by valves; (b) employs a constant speed pump of such design that the rate of discharge can be altered from zero to maximum. Constant volume systems are mainly used in hydraulic copying lathes, a gear or valve pump being used in the majority of cases. Pressure up to 1,000 lb./sq. in. can be obtained in special designs, uniform pressure being maintained in the system by a relief valve.

Where loadings are high, compressibility of the operating fluid, mainly due to entrapped air in the oil, will affect the accuracy of the system. Pressures of over 1,000 - 1,500 lb./sq. in. must be used to overcome this effect and since most systems work at a very much lower pressure than this (normally not above 500 lb./sq. in), care must be taken to see that air is excluded from the system. One of the principal sources of trouble for air entering the system is at the pressure relief valve and at the reservoir return. One patented system incorporates a return which causes the velocity of the oil to fall to zero before entering the reservoir. In addition, a large reservoir will not only help to keep the air at a constant temperature but also allow air bubbles to escape.

(TO BE CONTINUED)

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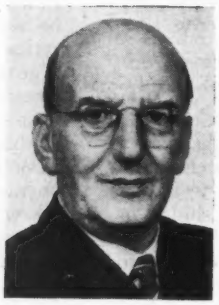
METALLIC MATERIALS AND PROCESS DEVELOPMENT FOR AIRFRAME APPLICATIONS

by S. G. E. NASH, M.I.Prod.E., A.F.R.Ae.S.



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THE purpose of this Paper is not so much to give special consideration to the materials lately being adopted for airframe use, as to effect some comparison between them and the materials which have been in use for much longer periods, as for example, in conventional aluminium alloy designs. To effect such a comparison involves an attempt to bridge the gap between the kinds of thinking of the design engineer, who starts every new design with an unhampered choice of materials — considering mainly suitability for purpose as a criterion — and the true production engineer, whose established techniques may need drastic revision in the light of the introduction of new materials or even of familiar materials in new forms. Such changes may well entail considerable limitation in the choice of the production engineer as to how to build the airframe, imposed by such considerations as the sizes of sheet material available, etc.

Later in the Paper, there are some references to development of processes for working the materials under review, since the most efficient materials in the world represent no advance if they cannot be obtained — or put reasonably easily and economically into the chosen configuration of the particular product.

static strength and stiffness considerations

To deal with the basic physical properties of the materials by stages it is convenient to consider first the tensile properties and to compare their tensile strengths, both in absolute terms and in relation to their density, or strength to weight ratio. Columns 2 and 5 of Fig. 1 give this comparison. As somewhat of an over-simplification the higher-strength ranges of each particular class of material, as—for example—magnesium and aluminium alloys, commercially-pure and alloyed titanium, stainless steels, are selected as typical in order to avoid the complexity of overlapping specification strength ranges for the same product. Also, the question of proof stresses in relation to ultimate stresses is ignored; sometimes this limits the effective design stress, as for example in the higher-strength steels and titaniums, where the proof stress is a high proportion of the ultimate.

If design in tension — such as in the bottom surface of an outer wing in flight — were the sole criterion, then one would pick the material with the highest specific strength, according to Column 5 of Fig. 1 and the choice of materials would be beryllium (K), titanium alloys (F) (E), aluminium alloys (G) (H), stainless steel (C), in that order.

But stiffness considerations must also be satisfied to avoid such aero-elastic effects as aileron reversal. (Back in the 1920's some aircraft exhibited this effect in which when left aileron was applied the aircraft banked right, because the wing was not stiff enough to resist the aileron loads and it twisted until the change in incidence overcame the effect of the aileron). This kind of stiffness property can be compared specifically as stiffness/weight ratio or Young's Modulus "E" divided by density, as in Column 6 of Fig. 1. On this criterion — and apart from beryllium — there is much less to choose between the various materials.

However, not all the design of aircraft structure is settled by simple considerations of tensile strength and stiffness. Remembering the reversal of load on

any particular component that takes place as between different aircraft manoeuvres, as, for example, the bottom surface of an outer wing being in tension in flight and in compression in landing, probably more of the surfaces are designed by compression loadings than are designed by tension. Allowable compression loadings are much more a characteristic of the geometry of the part for reasons of instability and are more difficult of presentation. Making certain overall assumptions about similarity of loading and geometry, an index to performance can be expressed by $\sqrt{E}$ divided by density as in Column 7 of Fig. 1. By this index, the light alloys show much more favourably; another way of assessing their virtue is that for the same strength in compression they can be thicker. Obviously, this conduces to an easier problem in handling and working and is much more attractive from the production engineering aspect.

fatigue considerations

Such comparisons of materials as have been made in the foregoing section apply to static stressing considerations, when the flight manoeuvres have been suitably reduced to applied loadings. It is, however, broadly true that with the first post-War generation of civil aircraft a deliberate policy of design for fatigue was instituted and the main reason for this was the much longer expectation of life required, say 30,000 flying hours for a civil airliner then; now, the requirement would be 40,000 hours. Probably 300 hours would have been quite a long life for last-War military aircraft, outside of Coastal Command duties.

Fatigue and similar considerations often indicate the necessity for a conservative approach to the use of materials. For example, although the static strength of an aluminium alloy as applying directly to the tension surface of a wing may be in the 27 - 35 tons/in.^{2} range, the designer may not think it prudent to work beyond 22 tons/in.^{2} or even 20. It is the tension loading that is the significant one and the stress concentration round the edges of holes, at joints and sharp changes of section that is the destructive

TENSILE STRENGTH / DENSITY AND MODULUS OF ELASTICITY / DENSITY RATIOS FOR SELECTED MATERIALS AT ROOM TEMPERATURE.

	1 MATERIAL.	2 TENSILE STRENGTH (tons / sq. in.)	3 DENSITY (lb./cu. inch)	4 MODULUS (lb./in.^{2} x 10^{-6})	5 U.T.S. / DENSITY (x 10^6)	6 MODULUS / DENSITY (x 10^6)	7 √MODULUS / DENSITY (x 10^6)
A	STAINLESS STEEL (SOFT) (18/8 Cr./Ni.)	40	0·283	29	0·32	103	19·0
B	STAINLESS STEEL (18/8 Cr./Ni.)	65	0·283	27	0·51	95	18·4
C	STAINLESS STEEL (12% Cr. COMPLEX)	70	0·283	31	0·55	109	19·7
D	TITANIUM (COMM. PURE)	30	0·163	15	0·41	92	23·8
E	TITANIUM ALLOY (5% Al. 2½% Sn)	60	0·163	155	0·82	95	24·2
F	TITANIUM ALLOY (4% Al. 4% Mn)	70	0·163	16	0·96	98	24·5
G	ALUMINIUM ALLOY (HIGH ROOM TEMP STRENGTH)	35	0·100	10·5	0·78	105	32·4
H	ALUMINIUM ALLOY (HEAT RESISTANT)	30	0·103	10·5	0·65	102	31·4
J	Mg. Zr. Th. ALLOY.	15	0·07	6·3	0·48	90	35·9
K	BERYLLIUM (COMM. PURE)	30	0·066	44	1·02	665	100

Fig. 1. Table of specific strengths and stiffnesses.

factor; hence the pressure on the production engineer to adopt techniques that improve the geometry of the joints as much as possible.

What is of concern in this section of the Paper is not so much to compare the performance of the various materials as to emphasise the importance of fatigue as a direct design criterion, and the significance of the considerable bulk of test information available.

Fig. 2 shows this evidence as presented in the Royal Aeronautical Society's series of data sheets; it summarises the results of some hundreds of tests on aircraft structural joints in the commoner aluminium alloy materials as three curves; A is the mean of all results, B and C are the higher and lower limits of expected performance. Together these give a ready index of performance against which *ad hoc* results on particular designs may be judged, and a ready indication gained of the necessity or otherwise of further

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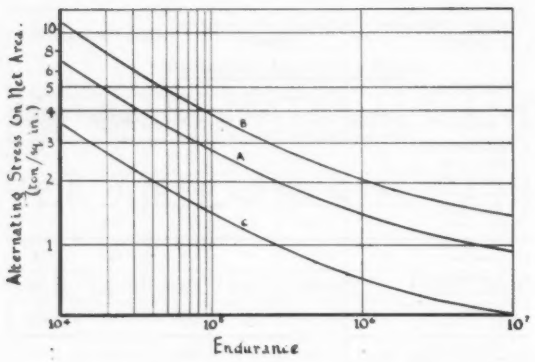
Mr. Nash commenced his engineering career in 1926 *as an apprentice at the Royal Aircraft Establishment. In* 1932, *he joined the Bristol Aeroplane Company as a test assistant, specialising later in mechanical testing and the application of materials. In* 1944, *he became the first head of the Company's Aircraft Division Structural Research Laboratory and, in* 1950, *Quality Manager. A return to development work followed in* 1954 *and in* 1957 *he became Chief Development Engineer (Metals). He took up his present position as Head of Materials Laboratories in* 1958.

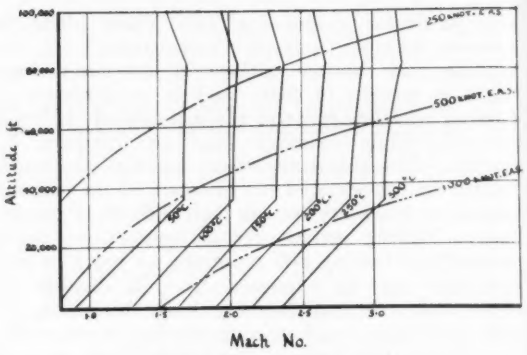
Since his election to membership of The Institution of Production Engineers in 1952, *Mr. Nash has served, more or less continuously, on the Research and Technical Committee, and is Vice-Chairman of its Material Utilisation Sub-Committee. He also represents the Institution on several B.S.I. and other Committees. He has been a member of the Western Section Committee since* 1952, *and is at present Chairman both of the Western Section and of the South Western Region.*

The Paper published here is based on a lecture given to the Western Section at Weston-super-Mare on 25*th February,* 1959.



ENDURANCES OF STRUCTURAL JOINTS
(ALUMINIUM ALLOY MATERIAL - TENSILE LOADING)

Fig. 2. Design fatigue curves for aluminium alloy joints.



EQUILIBRIUM TEMPERATURE CONTOURS.

Fig. 3. Temperature variation with speed and altitude.

refinement in design or manufacturing method. In fatigue work, it is a usual convention to assess performance by the showing at 2×10^6 reversals of the fluctuating load. Thus, on Curve A, failure at a life of 2×10^6 applications can be expected at a fluctuating stress of only about $1\frac{1}{4}$ tons/in.^{2} superimposed on a steady applied stress of some 4 - 7 tons/in.^{2}, but the static ultimate stress of the material of the joint would be some 27 - 35 tons/in.^{2}. While this bulk of information has already been collected and analysed for aluminium alloy structural materials, assessment of structural fatigue performance on the newer materials as they are introduced into use will be necessary to give the same degree of confidence. Many other aspects of fatigue, such as the influence of corrosion, internal stress, arising from heat-treatment and other causes, assembly stresses and the like, will need similar assessment.

TENSILE STRENGTH / DENSITY AGAINST TEMPERATURE

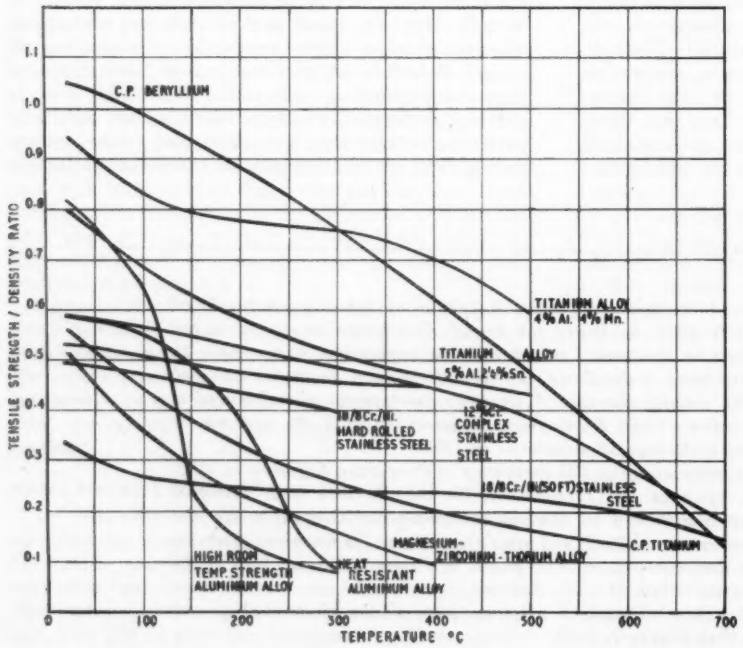


Fig. 4. Specific strength variation with temperature.

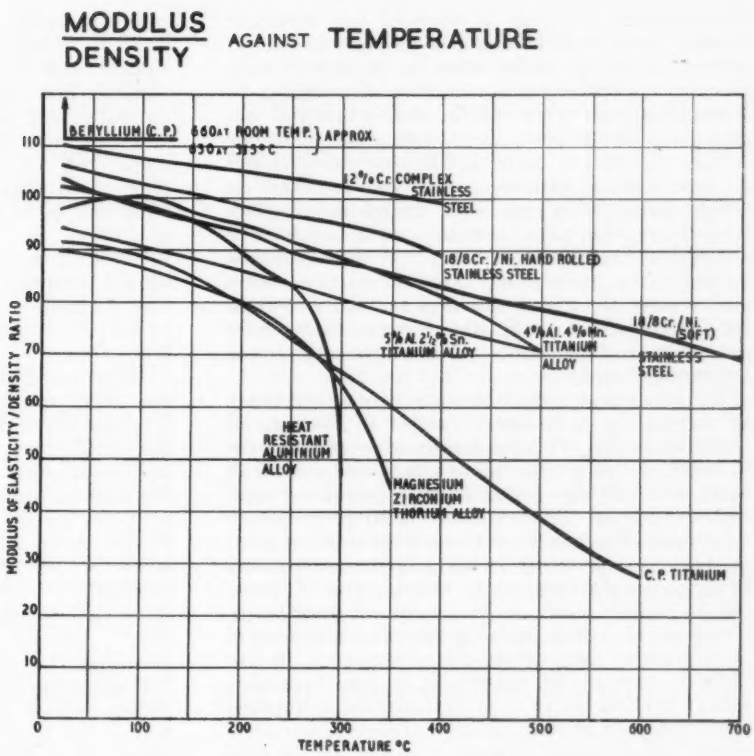


Fig. 5. Specific stiffness variation with temperature.

temperature considerations

It is, of course, the desire to fly ever faster that introduces the effects of kinetic heating and the necessity to use more highly temperature-resistant materials. The temperatures involved for the practicable aeroplane régime are shown in Fig. 3, presented as a carpet plot of altitude against Mach number, the speed of sound at the particular altitude, some 760 m.p.h. at sea level and 660 m.p.h. at 36,000 ft. approximately. Superimposed are the curves for equivalent air speeds of 250, 500 and 1,000 knots, and also lines of equilibrium temperature assuming sufficient time at constant speed to reach that temperature.

Among other things, the curves show why it is not a good thing to fly really fast at low altitude. Thus, at 20,000 ft. the 500 knot aircraft reaches only some 30 - 40°C, whereas the 1,000 knot one reaches 200°C; under the former condition material properties will scarcely have been affected at all, but they present a very real problem at the latter. Civil airliners in service now are based structurally on the use of aluminium alloys and except perhaps in some critical locations, where other materials may be preferred, there are no resulting disabilities.

However, with increases in speed to Mach 2 and 3 — commonly considered as the speed range appropriate for the next generation of civil airliners — the temperatures can be seen from Fig. 3 to be sufficient to result in considerable decreases in both strength and stiffness. Comparisons of both specific strength and stiffness, on the same basis as used for the room temperature properties in the Table of Fig. 1, are plotted against temperature in Figs. 4 and 5.

Dealing first with strength only, it is clear from Fig. 4 that aluminium alloys strong at room temperature are suffering drastic decrease in strength at a little over 100°C, whereas the heat-resistant variety has reasonable strength up to approaching 200°C, the two stronger stainless steels are still reasonable up to nearly 500°C, and the heat-resistant titanium is outstandingly the best.

From the stiffness aspects of Fig. 5, the heat-resistant aluminium alloy suffers serious decrease by about 200°C, and the two stronger stainless steels are clearly superior to both aluminium alloys and titanium alloys.

One important deduction, if we consider the trends from these curves, is that each material has its own particular range where it shows up best. Thus, considering strength and stiffness aspects in combination, at about 500 - 600°C — which might be appropriate to long-range missile conditions — we have passed the range at which titanium would be the best choice.

general commentary on materials

A fair number of aircraft materials have been omitted from Figs. 4 and 5 in order to emphasise the general trends more clearly. Also, some particular applications are for other reasons than specific strength and stiffness. For example, the use of com-

mercially-pure titanium in place of soft austenitic stainless steels in fire-walls and jet-pipe shrouds of present airliners is rather more for reasons of resistance to a specified flame without undue scaling. In Bristol Britannia, some 400 lb. of this material was used for airframe parts alone, with a saving on the relative densities of some 280 lb.; no small matter in these days of penalties in aircraft contracts on weight, performance, etc., even though the titanium itself costs considerably more per pound weight.

Another feature which does not emerge from the figures is the striking improvement in temperature performance of some of the more familiar materials, for example, as with the newer magnesium-zirconium-thorium alloys, within their appropriate temperature range.

Special mention might be made here of beryllium, at present the glamourous member of the aircraft materials family. With the density of magnesium, the strength of strong aluminium alloys, one-and-a-half times the stiffness of steel, the specific strength exceeds that of all the other materials previously mentioned. The specific stiffness is six times as great as the best and overall it has a better temperature performance than any up to temperatures of nearly 650°C. While there is great aircraft interest in beryllium, all current British production is devoted to atomic energy uses, where the advantage is its low neutron capture. At present, it is very expensive, some five times the price of titanium and a hundred times the price of stainless steel. However, price is a matter which should be kept in perspective; in 1850 — some 25 years after it was first isolated — aluminium was still dearer than gold! Beryllium needs also specially careful handling on account of its high toxicity in the powder form, and the fact that any wounds with retained beryllium are reluctant to heal.

The virtues of beryllium as an alloying element are well-known; what is new is the manufacture of the metallic form in bulk. There are rumours of its use as sheet in hypersonic American aircraft projects, but it is difficult to substantiate such use.

availability of various forms of material

Against such basic considerations of the properties of various types of material over the required ranges of temperature, production engineering factors arise in the sense of assessing the materials as to how well the forms in which they are available fit — or can be made to fit — the needs. In this general assessment, some prominence is given to the particular form of sheet materials, since they are likely to constitute the major outside envelope of airframes, and the various materials are considered in order of ascending temperature resistance.

aluminium alloys

In the strong aluminium alloy field, sheets are available up to 16 ft. × 6 ft. × ¼ in. thick with tight weight control and with a good — though admittedly undefined — standard of flatness. At the lower end of the thickness scale are sheets as thin as 30 s.w.g., where weight control is not vital, still of adequate size for all the needs. Where once such sheets were hand-rolled to these standards, now they can be continuously rolled on the strip mills, and this applies equally well to the higher temperature resistant varieties. Both types can be supplied slightly softer as naturally aged to suit the manipulation sequences, and can then be precipitation hardened without major risk of distortion. For integrally-machined types of structure, slab material can be supplied as stretched, by virtue of new facilities, up to a size of 210 sq. in. cross section, say 60 in. × 3½ in. British-developed machine tools have been developed for the sculpture-machining of such forms of structure. Contour-etching by chemical means is another technique already in production use in British aircraft firms.

In general terms, this story could be repeated for the other forms of aluminium alloy material to illustrate the sophistication of the various forms of its manufacture to meet the requirements. Perhaps the outstanding facility lacking in this country is the manufacture of tapered sheets and that is largely a matter for the economics of demand and supply. By its use in matching the thickness of the sheets more or less precisely to the applied loading, probably 100 - 200 lb. weight could be pared off a large civil transport aircraft.

titanium

Considering titanium as next in the temperature-resistance scale, so far the majority use in British airframes has been for fire-walls and similar applications, rather than for the major structural envelope. Accordingly, the major production of the sheet form has been by hot-rolling of the commercially-pure varieties, within a limited size range probably up to 8 ft. × 3 ft., rather than of the stronger alloyed forms, which give the potential outlined earlier. British production of the latter is still on a relatively small scale.

For forming, it is often necessary to use tools heated to several hundred degrees Centigrade to achieve the desired configuration for some parts that in aluminium alloys would be made by cold Hufford stretch-forming operations; this applies to the commercially-pure and alloyed varieties alike. Although titanium has developed very quickly in this country to provide a wide range of products, it still has some way to go to achieve parity with aluminium alloys in the diversity and ease of methods of fabrication in the workshops and, of course, in the matter of price. Neither do we see yet in this country any evidence of the all-titanium alloy aircraft, although we hear of it — in the form of one of the Century fighters — from America.

One notable piece of development work in titanium for individual mention is the manufacture of close-tolerance aircraft bolts in the 4% aluminium - 4% manganese alloy at about 65 tons/in.^{2} ; these performed very creditably in fatigue and at temperatures of 300°C, giving results superior to their counterparts in steel at 55 - 65 tons/in.^{2}. Similarly, satisfactory results have been obtained from static shear tests with the Hi-Shear rivet type of fastener. One expects to see such applications in use before

long. Perhaps at slightly longer range, one hopes to see some more lightness added by the development of titanium tubes for high-pressure hydraulic services. More immediately, continuing work is necessary on applications of the titanium alloys in their more massive forms, such as forgings and extrusions, in order to extend present knowledge about such characteristics as galling and creep relaxation, notch sensitivity, etc.

In the field of the developments of titanium alloys themselves, the most interesting which applies to the sheet form is that recently announced by which the available strength can be increased considerably — up to 70 - 80 tons/in.^{2} or so — but in which the material is supplied solution heat-treated at 800°C to a rather lower strength of about 45 - 60 tons/in.^{2} with an elongation about 30%. These latter properties should give plenty of scope for the necessary fabrication processes before the final strength is achieved by a precipitation heat-treatment at about 525°C for some 16 - 20 hours. This kind of heat-treatment sequence is analogous to that practised on the elevated - temperature precipitation - hardening types of aluminium alloys and — conveniently enough — the precipitation temperature of 525°C coincides with the range of temperature used for the solution heat-treatment of aluminium alloys ; thus equipment problems are simplified. In applying such materials to large structural elements due regard must be given to volume change effects of about $\frac{1}{8}$%, which occur in the final precipitation heat-treatment, especially in relation to jigging problems.

austenitic stainless steels

Next in the order of temperature-resistance are the 18/8 chromium-nickel austenitic stainless steels, typified by the Staybrite F.D.P. family. These are widely used for domestic, food-processing and industrial applications in their softer varieties at about 35 tons/in.^{2}, as indeed they are also for airframe applications : the properties range is given in Figs. 1, 4 and 5.

For major structural airframes they are also used at a higher strength level of about 65 tons/in.^{2}. As welding or other exposure to high temperature is often involved, the chemical composition of this type of material is stabilised against weld decay by the addition of controlled amounts of titanium or niobium. Latterly, there has been some tendency to prefer niobium, on the grounds that under some conditions titanium carbide is prone to outcrop in the form of stringers or fissures. If this occurs, difficulties may arise in bending operations by brake-press or section-rolling methods, and in welding operations by the occurrence of porosity.

From the earlier figures, the specific strength at room and elevated temperatures is good; the specific stiffness as manufactured is a little low — with a Young's Modulus about 24.5 - 25 $\times$ 10^6 lb./in.^{2}, but this can be improved to about 27 - 27.5 $\times$ 10^6 by a final precipitation heat-treatment, which again works conveniently at about 525°C. As with the new titanium sheet, there is a small volume change, but it can be accommodated if final sizing and hole-drilling be left till after the heat-treatment.

From the practical aspect of providing material in a wide variety of sizes and forms for convenience of use, this austenitic stainless steel family probably offers the strongest challenge to the aluminium family, with the additional advantage of the greater high-temperature potential.

The sheet varieties derive their strength from cold-rolling, of which the finishing stages impart a highly-polished surface, a high — but again undefined — standard of flatness, and a high standard of thickness tolerance. Continuous strip - rolling facilities — analogous to those in the aluminium industry — provide sheets up to 14 s.w.g. thick, 1 metre wide and, say, 20 ft. long. The latter does not constitute an absolute limit, but rather a reasonable limit to what can be handled in the flat. Coils much longer can be supplied, but thin de-coiling equipment in the user's works becomes necessary. Outside these limits, single-sheet rolling provides sheets up to 12 ft. $\times$ 4 ft. $\times$ 7G; being cross-rolled at an early manufacturing stage, these do not exhibit quite the same directional properties as do the continuous strip-rolled materials. It follows from the cold-working considerations that the same high-strengths cannot be achieved in the massive forms like bars or forgings, but that they can in the tube form.

A fairly new development in plant provides very thin foil — down to 0.001 in. thick and 12 in. wide — which can be supplied in long coils. This facility will be invaluable if stainless steel honeycomb sandwich structure develops in this country as it has in America.

Future developments in this class of material indicate substantial increases in strength by precipitation hardening methods, rather similar to those already outlined for titanium. Steels utilising this principle are typified by Firth Vickers FV.520 and the American Armeo 17/7/PH. Broadly, the sequence of manufacture and treatment would be to hot and cold roll as usual, to soften at the normal temperature — about 1,050°C — and to descale. At this stage the strength would be some 50 - 60 tons/in.^{2}. Fabrication would follow at that stage, then a transformation treatment would follow either by heating to 700 - 750°C, or by sub-zero treatment at –50°C to –80°C ; finally a precipitation treatment at some 450 - 550°C would be necessary to achieve the strengths in the region of 70 - 85 tons/in.^{2} potentially available. Here again, a volume change of about 0.3% during transformation is involved.

Another line of development pursued is a slightly different composition from the usual 18/8, still basically the 18% chromium, but with the 8 - 9% nickel lowered to about 5$\frac{1}{2}$-7$\frac{1}{2}$% and the usual 1-2% manganese correspondingly increased to 5$\frac{1}{2}$ - 7$\frac{1}{2}$%. Here this material is known as Firth Vickers FSM.1; in America it is the 201 type. Its particular virtue is the ability to achieve a higher ductility. for the same strength than with the normal 18/8 variety, or a higher strength for the same ductility. Under conditions of nickel shortage, such as existed in the last War, the advantage would be considerable..

12% chromium complex stainless steels

Apart from its strength, this 12% chromium complex alloy stainless steel typified by Firth Vickers 448 steel has an outstanding attraction in its high elastic modulus, both at room and elevated temperatures. At room temperature the elastic modulus ranges betwen 30 and 32 $\times$ 10^6 lb./in.^{2}, compared with 28 - 30 for low alloy steels and 24.5 - 25.0 for the austenitic 18/8 stainless steels. This advantage, coupled with its high temperature-resistant characteristics, is sufficient to ensure its use both in the bar and forging forms, and also for compression structure in the sheet form at the expense of overcoming certain limitations of flatness.

It is interesting, too, in that it illustrates how metallurgical refinements in an alloy steel of a particular type lead to an extension of its uses into new applications. A steel generally similar to it was used in the airship R.101, where certain difficulties in its manipulation were encountered; there is little evidence of the aircraft use of such materials for 20 years or so, until the emergence of this Firth Vickers 448 type of steel, particularly suited to gas turbine disc applications in the aero engine field.

Unfortunately, from the aspects of smooth surface finish, flatness and continuous strip rolling, it derives its strength not from cold-rolling operations, but from hardening and tempering, so is subject to the distortions that occur in them. Thus, no very high degree of flatness can be achieved in any very sizeable sheet or plate sizes, and if such a high degree is required for reasons of aerodynamic smoothness or weight control it must be achieved by machining. From the machining aspect, the largest sizes of the plate or sheet form that can conveniently be handled are probably something of the order of 10 ft. $\times$ 4 ft. and it is possible to ameliorate the flatness problem in the manufacturing stages of plate by using the hammer-flattening technique common in armour plate work. In the latter, this technique is applied to sizes considerably bigger than the 10 ft. $\times$ 4 ft. mentioned above.

For the production engineer, such practices represent an activity at an unusual end of his scale, where the problem is not so much how to do the thing cheaper, faster, better, as how to do it at all.

This type of material, if it can be suited to the particular geometry of major structure, will suffice up to some 550°C, but beyond that is approaching its tempering temperature. For airframe applications that range would suffice for many years yet in terms of civil airliner requirements.

fabrication development work

In the introduction, some stress was laid on the importance of the ability to fabricate the selected materials into the desired configuration. The remainder of the Paper is devoted to an account of various aspects of fabrication development work on the classes of materials considered previously. This work includes the fastenings considered appropriate for them, and it is worth recalling that — besides orthodox bolting and riveting — many proprietary fastening methods are used; the latter will usually

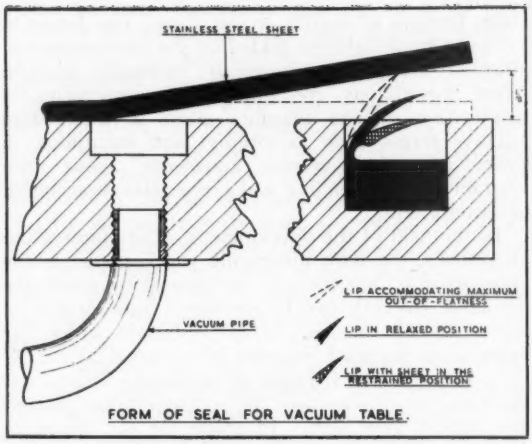

STAINLESS STEEL SHEET
VACUUM PIPE
LIP ACCOMMODATING MAXIMUM OUT-OF-FLATNESS
LIP IN RELAXED POSITION
LIP WITH SHEET IN THE RESTRAINED POSITION
FORM OF SEAL FOR VACUUM TABLE.

Fig. 6. Features of seal for vacuum table.

themselves have been evolved in terms of orthodox materials. Thus, when new materials are used for the major aircraft structure, or when it has to satisfy an additional requirement — like performance at temperature — it is necessary to re-appraise these proprietary fasteners. Often, to ensure compatibility with the structural materials or the performance of the fasteners themselves, their materials must be changed also. Such process development work involves the closest collaboration between the materials manufacturer, the fastener maker and the user if it is to be efficient and reasonably quick, since each interest has its own particular limitations.

sheet and plate materials

machining of plate

When machining plate material of the 12% chromium complex type of stainless steel described earlier, one major problem is the method of holding these plates down on to a vacuum table. In the particular application the plates were 8 ft. $\times$ 4 ft. $\times$ 0.4 in. thick. With aluminium alloys, this would present much less of a problem, the material being flat to start with and not very stiff; a low-volume capacity vacuum pump and probably an edge-seal of Plasticine might well suffice. The steel is three times as stiff and not very flat. The degree of out-of-flatness permissible in the plate as received is directly related to the capacity to suck it down on to a vacuum table, and thence to the ability to provide a seal that will accommodate a large deflection and still seal. For this purpose, seals of round section are obviously out of court.

Fig. 6 shows the seal eventually evolved, its main features being a rectangular base with a good fit to prevent leakage, a thinned hinge so that the lip may pass easily below table level but with the hinge well supported by the groove wall, a thickened portion above the hinge to prevent the lip being sucked inwards and a feather edge to the lip.

Other necessary arrangements for the vacuum table itself are a high volume capacity pump and a

big reservoir — one about 100 cu. ft. was successful — so that a high momentum can be imparted to the initial pulling down.

In investigating these problems, it was found to be a useful method to use sheet Perspex, as shown in Fig. 7, to study seal movement and to introduce wedges beneath them to stimulate out-of-flatness in the steel sheet. Thus, the vacuum table was developed to accommodate up to $\frac{3}{8}$ in. out-of-flatness and to leak only 5 in. of mercury over 12 hours, with no backing from the pump. Fig. 8 shows a plate with a fair degree of out-of-flatness, both lying free and clamped down to the table.

Even now there are no national standards for flatness of aircraft sheet or plate materials and consequently there has been little study of the topic. Hence, in parallel with the seal developments it was necessary to study sheet flatness and evolve domestic flatness standards. Eventually an overall limit of 0.175 in. and a local limit stipulating not more than 0.050 in. on any 9 in. chord length were imposed. For detection of the latter, an illuminated roller device, with its ends stepped down 0.050 in., provided a quick comparator; this was a product of a Works Suggestion Scheme.

stretch-forming of austenitic stainless steels

For high volume production of contoured components, the Hufford stretch-wrap process is much used in the aircraft industry, particularly for the fabrication of aluminium alloy components. With the normal 18/8 austenitic steels in the hard-rolled condition at about 65 tons/in.^{2}, however, this process cannot be used with certainty for components requiring a high degree of permanent strain; there is a tendency to failure before full contour is achieved and it is more pronounced with the continuous strip-rolled variety of material than it is with the individually-rolled sheets. Some recent experimental work on a fairly large scale appropriate to contours of fuselage skinning confirmed this effect, and also the greater formability of the FSM.1 variety of this class of material at the same strength.

The difference between the performance of the two materials is thought to be less a matter of the available elongation than it is of the stress-strain characteristics after the material starts to strain plastically. Figs. 9 and 10 show the stress-strain characteristics measured to failure; for the normal 18/8 material there is a very sharp breakaway in the stage of final elongation to failure, but with the FSM.1 this stage still exhibits an increase in stress — and hence of load — for increasing strain. With the latter, there is implicit more control of the stretching.

mechanical fastening methods

Contrary to the aerodynamicists' dream of smooth, sweeping unbroken surfaces, the reality is many separate pieces — joined by hundreds of thousands of assorted fasteners! In essence, for reasons of flushness, the problem is that of the countersunk head, often thicker than the sheet thickness involved. Every aircraft concern develops its own preferred method of achieving flushness. One way is to

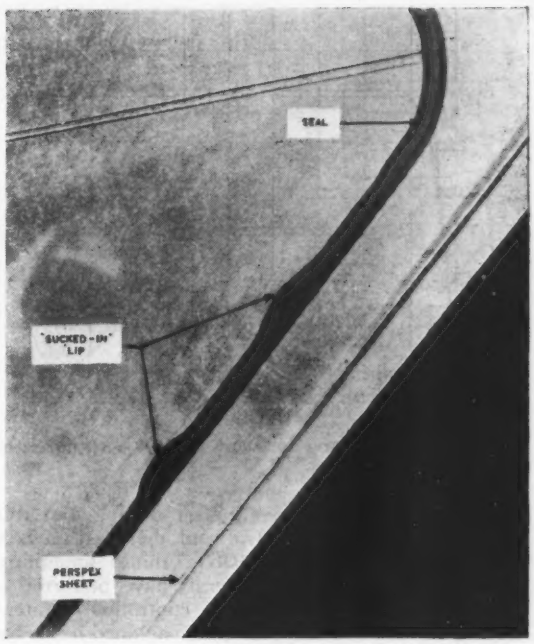


Fig. 7.

Sheet standing free on table

Fig. 8.
'G' clamp applied free edge of sheet over $\frac{3}{8}$ in. from surface of table

Figs. 7 and 8. Performance of vacuum table.

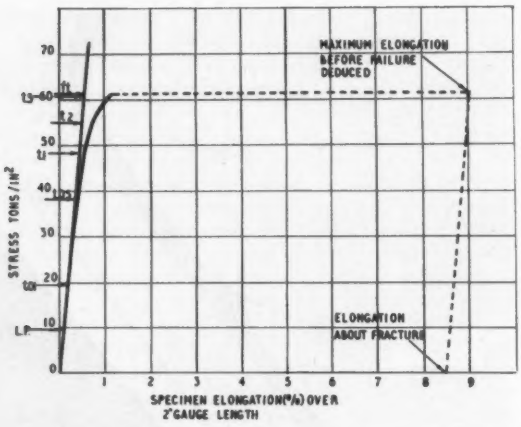


Fig. 9. Stress-strain curve to failure for 18/8 austenitic steel.

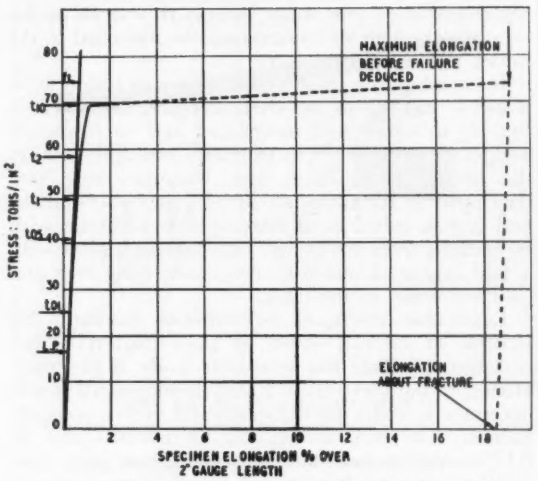


Fig. 10. Stress-strain curve to failure for FSM.1 steel.

machine the heads of rivets after driving, but this demands immaculate control and there are always risks of skin damage — 0.036 in. minus something leaves very little! Bristol Aircraft have preferred a policy of using, in conjunction, controlled countersinking or dimpling and precision-machined heads on rivets and other fasteners. For thin sheet, the method of squeezing between male and female dies does not produce clearly-defined, accurate dimples.

Spin-dimpling. For these reasons, the Bristol spin-dimpling method shown in Fig. 11 was developed originally for aluminium alloy materials; it produces an appearance very similar to that of cut-countersinking. It achieves an overall flushness standard within $^{+0}_{+0.005}$ in. and is used for some 90% of all dimpled holes in Bristol Britannia. In the method, a male "spinning-bit" flows the material into a stationary female die; the "sprue" at the dimple edge is removed by a cutter device, and the swarf blown out by air blast, all embodied in the machine head. Close inspection control is maintained, but the machine — once set — functions automatically. Breakdown into panel assemblies is, of course, implicit.

A portable variant of this process provides for working in the assembled state, or for repair work.

This spin-dimpling process, since its development for aluminium alloys, has been successfully applied to the softer varieties of both titanium and stainless steels. For the stronger varieties of both, although physically the dimpling can be achieved to acceptable dimensional standards, the question arises of the effect of it on the material and there are certain limitations.

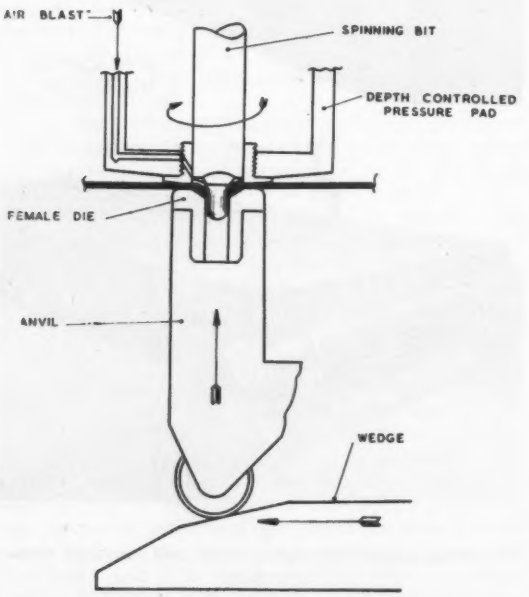


Fig. 11. The Bristol spin-dimpling process.

Solid riveting. With aluminium alloy constructions there are few problems apart from those of quality control to ensure consistency of rivet and heading method. With steels, however, there has always been something of a limitation on the strength and quality of materials suitable for rivet manufacture and cold-heading. Some 20 years ago stainless steel rivets were used; rather interestingly, they were of the same composition as used for the strip components of the R.101 airship. They also had their troubles — the heads sometimes flew off during riveting.

More recently, experiments with the 12% chromium complex stainless steel FV.448 have given a good deal of satisfaction, and this at a strength of 70 - 80 tons/in.² — Fig. 12 shows a sample of it. Here, the limitation is rather more one of the riveting force that can be brought to bear by squeeze or percussion equipment than it is of the rivet material.

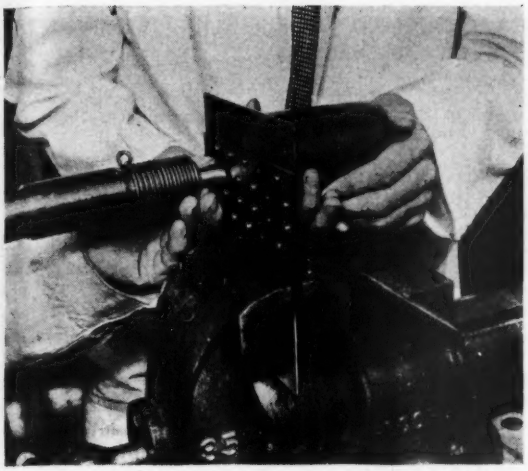


Fig. 12. High-strength steel riveting.

Hi-Shear riveting. The Hi-Shear riveting method is an ingenious American device (it is made in this country by Brown Bros.) that goes a long way towards removing the limitation of available riveting load. It is a kind of hybrid between a nut-and-bolt and a riveted joint, applicable wherever there is free access from both sides, where subsequent dismantling is not required and where the very highest tensile loads are not applied to the fastener itself. The tail of the rivet itself is not subject to the setting force, and the softer collar can be set rapidly and neatly. Among its advantages are significant weight savings over bolted joints and the fact that no particular operator-vigilance is necessary to observe closeness of dimensions of the rivet rail, to ensure adequate strength.

While originally the Hi-Shear rivet was made in orthodox alloy steels, British versions in both the FV.448 steel and the high-strength titanium 4% aluminium - 4% manganese alloy materials have already been successfully developed and tested; Fig. 13 illustrates the principle of the method.

Jo-Bolt blind riveting. For aluminium alloy construction, there are many well-known blind fasteners, a facility equally necessary in the higher strength titanium and stainless steel forms of construction. Fig. 14 shows the principle of the three-part Jo-Bolt, marketed in this country by Aviation Developments Ltd. It has a family likeness to the Hi-Shear rivet in that the bolt and nut components suffer little or no deformation, and so can be of high-strength steel. Again, the original versions were in orthodox alloy steels, but their counterparts in the FV.448 steel have been fully developed.

P.L.I. washers. With increasing preoccupation with fatigue performance over a long life, it is increasingly necessary to tighten bolted joints to a known tension in the bolts, to guard against the twin troubles at

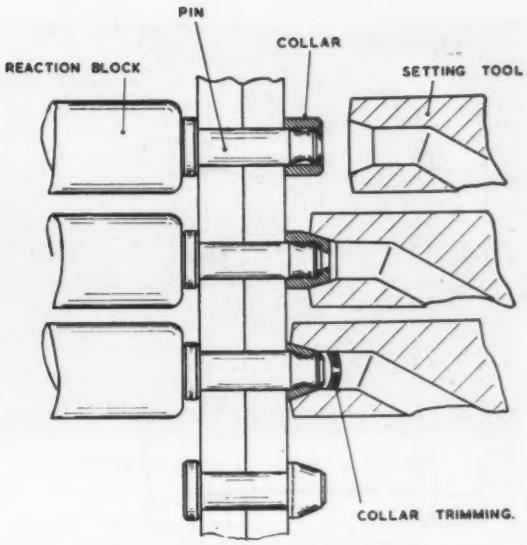


Fig. 13. Hi-Shear riveting process.

opposite ends of the scale of nuts loosening and bolts breaking, and to improve the fatigue performance itself. Poor access and scatter in performance often limit the use of torque spanners. The Pre-Load Indicating washer, of American origin, but in supply in this country by the Unbrako Socket Screw Co., provides a convenient method, even if it is a little more cumbersome and involves some expense of weight.

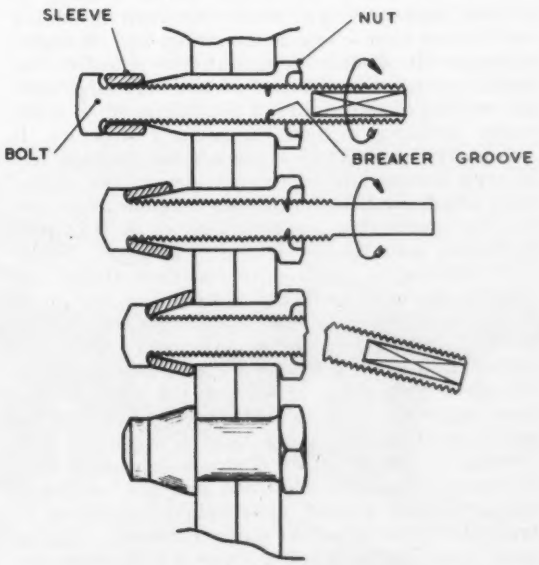


Fig. 14. Jo-Bolt blind riveting process.

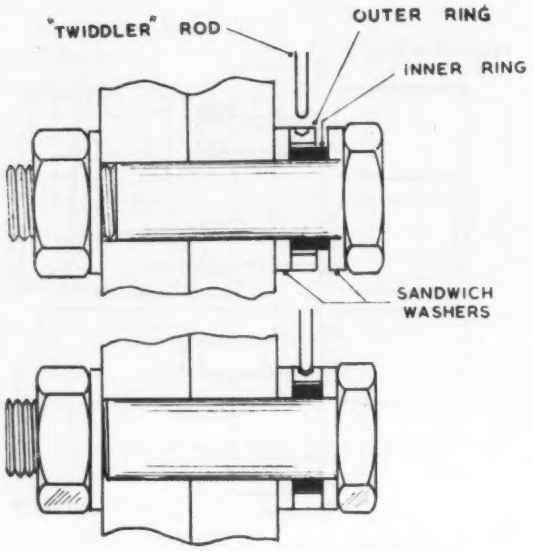


Fig. 15. The Pre-Load Indicating washer.

As shown in Fig. 15, the washer utilises the compression of a metal washer or sleeve to indicate the applied load; it is packed as a unit assembly, graded to suit the tensile strength of the bolts with which it is to be used. Versions of it exist in orthodox alloy steels as well as in the FV.448 steel.

fastening by welding

Over the years, the major use of welding in primary load-carrying structures has been on tubular steel frames such as engine mountings and on undercarriages. It is only comparatively recently that British aircraft have utilised on any very large scale the welding of sheet forms of aluminium alloys as the major fastening method for primary structure. It will be very interesting to see whether welding will be used increasingly on the new generations of aircraft which are likely to use the titanium alloys and stainless steels. The author's forecast is that such increasing use is likely.

If welding is adopted on stainless steels, one method developed at Bristol Aircraft Ltd. for use on the austenitic stainless steels and for joining them to the 12% chromium complex ones might find favour. Although little work has been done it appears to be suitable for titanium, at least in the commercially pure varieties. Locally the process is known as puddle-welding, and it is a form of argon-arc spot-welding, in which an arc is struck between a non-consumable tungsten electrode and the workpiece itself. Pressure applied need only be sufficient to bring the workpieces into intimate contact: that is, there is no forging action as there is with resistance-welding. The electrode itself does not touch the work. Advantages of the method are:

1. welds can be made where torch access is from one side only;
2. penetration can be controlled to give a good external surface, without pressure indentation, depending on thickness;
3. equipment is very cheap compared with that for resistance welding.

Fig. 16 shows the application for which the method was originally developed — the manufacture of free flight models in austenitic stainless steels of about 22 s.w.g. thickness. In that application each skin has the angle-section stiffeners welded to it; then the corresponding angle-section stiffeners on each skin are welded to each other through the free flanges. The access to join the two halves — each with its stiffeners already attached — is very limited, something just over $\frac{1}{2}$ in. Early attempts to utilise resistance welding were not successful; obviously some special-purpose equipment would have been necessary. This method has been applied over a fairly wide range of thicknesses.

For this process, the important parameters are current, time-cycle, arc-length, electrode diameter, shroud-diameter as affecting argon-flow in its relation to flange-width and backing-plate conditions. All except current and time-cycle are predetermined in the assembly of the apparatus and jigging arrangements. Current and time-cycle can be determined for the particular conditions and set on the appropriate controls of the equipment itself. Current decay relay arrangements are included to control through cooling rate any tendency towards secondary piping and associated cracks in the weld puddle.

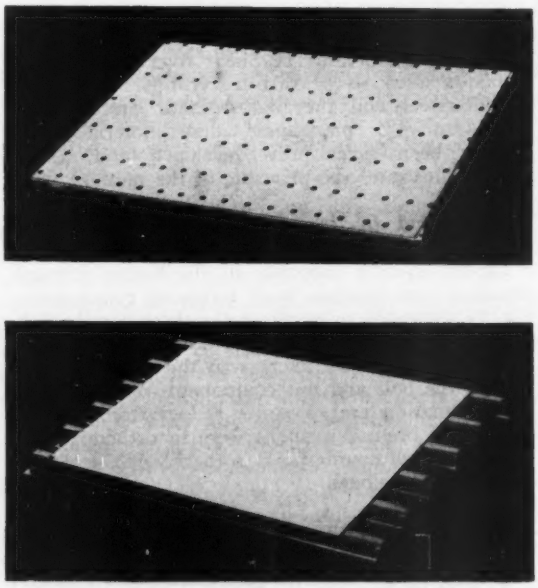


Fig. 16. Puddle-welding in free-flight models.

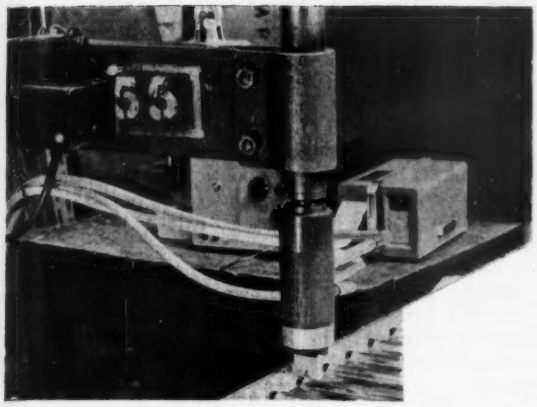


Fig. 17. Pedestal form of puddle-welding equipment.

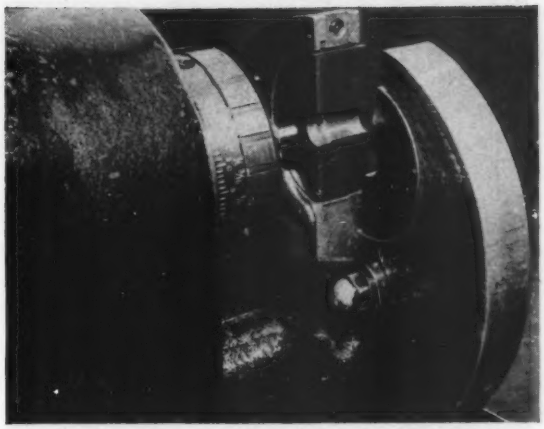


Fig. 18. Tools for the Bristol special bell.

Development equipment is shown in Fig. 17 as a pedestal machine version; the more portable torch heads are not shown. In the background is a pen-recorder device developed for monitoring the welding cycle to record time and current, as an inspectional aid. By its use, during a long run of welding under the same conditions, an inspector can monitor half-a-dozen welds or so from time to time, at his discretion, to assure himself that the characteristic current/time-cycle curve has not altered.

pipe-working processes

From the inception of hydraulic systems in British aircraft, the traditional materials for the pipes themselves have been copper alloys and special brasses, usually Tungum or Monel. With working pressures now at 4,000 lb./in.^{2} (=6,000 lb./in.^{2} proof), with fatigue problems looming larger and elevated temperature requirements imminent, the 18/8 austenitic stainless steels are beginning to be used. Even at normal operating temperatures, they offer weight-savings on a strength-density basis.

Because the peripheral strain involved in making the conical flares or bells for the conventional A.G.S. type of hydraulic connections is high — some 50 - 60% — these operations are often accompanied by a good deal of scrap, even if it occurs only sporadically. For this reason considerable attention is necessary to the finish of the bores of the tubes, whatever materials are utilised, and special inspection requirements are often directed to this feature.

Another approach to the same problem is offered by the design of a special Bristol pipe-coupling for use with stainless steel pipes; the tools for the pipe-end are illustrated in Fig. 18. The design is aimed specifically at keeping the strain in the bell-mouth down to a minimum of about 25% in order to reduce the effect of local stress-raisers such as draw marks. Draw marks are always to be eliminated or closely controlled to the minimum, however, as they provide hydraulic leak paths.

From the aspect of fatigue performance under fluctuating pressure conditions, ovality in hydraulic pipe bends is another feature currently demanding

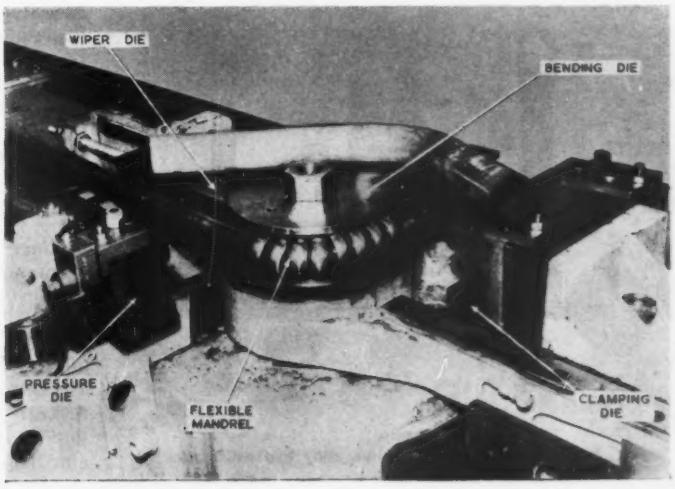


Fig. 19. Pines-bending of thin-walled stainless steel tubes.

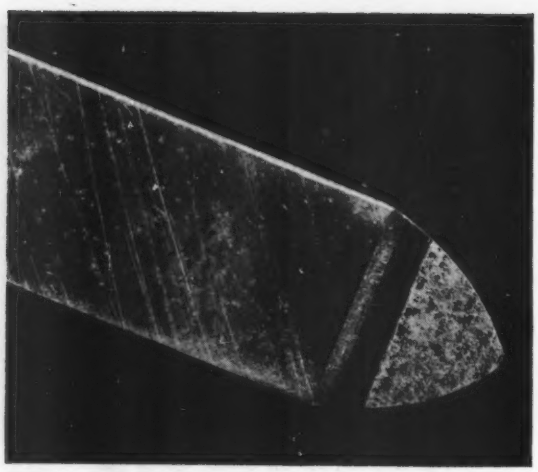


Fig. 20. Spark-erosion treated surface of lathe tool.

close control. Possible solutions to it include the use of more sophisticated tooling and the pressurising of pipes to induce plastic deformation and reduce ovality.

For the needs of fuel and air systems in modern aircraft, large-diameter thin-walled pipes are necessary. In the austenitic stainless steel materials, typical sizes are 1½ in. diameter and upwards, in 30 s.w.g. thickness ; for convenience of installation, inside bend radii as low as 3 × pipe diameter are required. Such requirements imply the use of pipe bending machines which are extremely stiff and accurate and which utilise associated tooling of a very high order of sophistication, to exert a maximum degree of constraint on the tubing, particularly at the point of bend. Fig. 19 shows an American Pines tube bending machine equipped for such work at Bristol Aircraft Ltd.

machining processes

No previous mention has been made of the ultra high-tensile steels — those of over 100 tons/in.² tensile strength, because their use in aircraft is still very restricted.

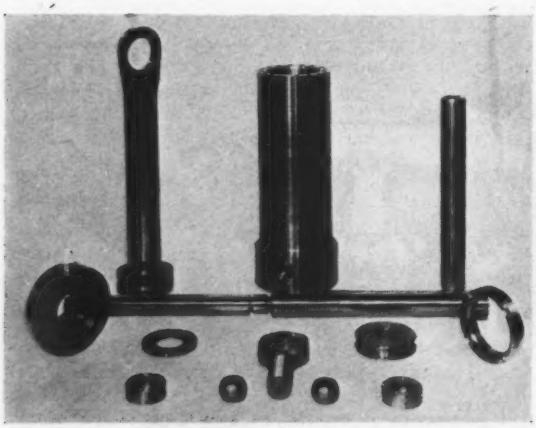


Fig. 21. Components for titanium alloy hydrauiic jack.

Spark treatment of tools. Machining such steels in the hardened and tempered state is somewhat arduous, because of the necessity for frequent regrinding of tools. Some alleviation can be gained by surface-treatment to the rake faces of lathe tools particularly, and to a lesser extent with milling cutters.

Early trials were made by the spark-erosion method, with results as shown in Fig. 20, but more recently grit- and shot-blasting have been found equally effective. The life advantage varies widely, but may be as high as 4 or 5 : 1. It is not at all clear whether the advantage proceeds merely from destroying the directional grinding marks and replacing it with a non-directional texture better able to retain lubricant, or whether some other mechanism is responsible.

Some of the more highly alloyed tool steels lately seem to achieve as good results — and perhaps more consistently — as the surface treatments.

Machining of titanium alloys. Production experience of machining the more massive forms of the strong titanium alloys is still fairly limited, but development experiences generally appear to agree well. Mostly they have been derived on the 4% aluminium - 4% manganese variety of about 70 tons/in.².

As generalities, it may be said that such alloys behave very much like stainless steels in machining, that a very high degree of machine tool stiffness is required, that the edges of cutting tools must be kept sharp and never allowed to rub, even momentarily, at the peril of immediate breakdown.

Of all the machining operations drilling, tapping and broaching appear the most difficult. It is difficult to obtain round, accurate holes from initial drilling; a final opening-up is necessary. Standard helix drills with conventional web thicknesses, but with "crankshaft" or "split" points, are beneficial. Standard series taps, cylindrically ground, allow excessive rubbing, high friction and tap-breakage. Provision of clearance by grinding a backing-off angle from the cutting edges of the tap, and also by truncating the thread form to achieve full depth by successive operations, is advantageous.

Fig. 21 depicts components for an experimental hydraulic jack in titanium alloy, aimed at assessing the galling and friction characteristics of titanium alloy. With the material in the "as machined" state, some 300 cycles of low-load cycling were enough to produce deep scores. At this stage, the normal hard-chromium plated surfaces were applied, and high-load cycling up to 100,000 cycles at temperatures up to 200°C followed without undue wear.

acknowledgments

The author would tender his thanks to Bristol Aircraft Ltd. for their permission to publish this Paper, and to his colleagues and staff for considerable assistance in the preparation of it.

THE MATERIALS HANDLING GROUP

A Report by the Chairman,

F. E. RATTLIDGE, A.M.I.Prod.E.

IT is perhaps appropriate that the first issue of the Journal in its new form should contain a report of the work of the Institution's Materials Handling Group, which is about to embark on a new phase of activity.

Basically, the main aim of the Group is to encourage thinking on ways and means of eliminating handling of material throughout any organisation and also, what is of equal importance, the general effect of these techniques on production activities. It is the considered opinion of the Group Committee that there are considerable savings to be made by improvements in materials handling and control and it is hoped that during the coming year a report covering this field, showing clearly the benefits that will accrue from the study and solution of such problems, will be published.

A brief survey of the history of the Group will help to bring this new view into perspective.

Following the visit of the Anglo-American Productivity Team to the U.S.A. in 1950 to study Materials Handling, a Materials Handling Sub-Committee was set up by the Research Committee under the Chairmanship of Mr. W. J. Webb. Its terms of reference were :

(a) to devise ways and means of stimulating interest throughout the Institution in the subject of Materials Handling as a tool of production;

(b) to draw up a definite programme of research which the Institution might tackle, with a view to producing a report on Materials Handling in industry.

(c) to make recommendations to the main Research Committee from time to time.

During 1951, Mr. T. W. Elkington was elected Chairman, and during his period of office the terms of reference were further expanded as follows :-

(a) to establish the Institution as a national authoritative body dealing with Materials Handling from administrative and technical aspects;

(b) to stimulate interest and to encourage, by education, an exchange of administration and technical knowledge in Materials Handling subjects.

In February, 1954, the Sub-Committee was reconstituted, retaining 10 of its original members, and an additional term of reference was added : to co-operate with other appropriate bodies in the field of Materials Handling. In November, 1954, there was a change of Chairman, and Mr. A. G. Hayek took the place of Mr. Elkington.

Its early success encouraged the Materials Handling Sub-Committee to expand its activities and discussions were held in 1954 about the possibility of the formation of a Group. Consideration of this matter and the formation of definite proposals took some time, but in April, 1957, the Council of the Institution established "The Materials Handling Group".

One of the first tasks of the new Group Committee was to extend their activity in the Sections, and to this end it was suggested that Sections should nominate an individual to be responsible for Materials Handling activities within their own area. It was encouraging for the Group Committee to have replies from 21 Sections, nominating their representatives. It was important to note that these representatives were given considerable freedom of action and were encouraged to organise their own Section activities, the Group Committee acting as a co-ordinating body. The Group's terms of reference are as follows :-

1. to provide a central forum for those members of the Institution having a special interest in Materials Handling. For this purpose Materials Handling is defined as :
   the study of the handling or other movement of materials before, during, or after processes in every type of industrial activity. This study shall be directed particularly to minimising and mechanising such movement;
2. to organise conferences and lecture meetings, encourage the writing of original Papers, prepare case studies for publication, establish working parties and in other ways stimulate interest in and build up a body of knowledge of Materials Handling directly or by liaison with other bodies;
3. to advise the Council and Committees of the Institution on matters relating to Materials Handling;

4. to recommend to Council the appointment of Institution representatives to other bodies concerned with Materials Handling; and,
5. through the Education Committee, to act as a consultative body on educational matters relating to Materials Handling.

Owing to changing circumstances the Group keeps these terms of reference continually under review and it is likely that various changes will be made in the near future.

Mr. Hayek remained Chairman of the Group until the end of 1958, when owing to pressure of business he was forced to retire and the writer was elected in his place.

activities

During the early part of the Sub-Committee's career the main activity was in the field of publications and mention of this will be made later. However, in June, 1952, the Sub-Committee organised a one-day conference at the Mechanical Handling Exhibition and was fortunate in having Major General K. C. Appleyard, then President of the Institution, to take the Chair during the morning session; while Mr. T. W. Elkington, the Sub-Committee Chairman, was in the Chair for the afternoon. In addition, the Institution had a stand at this exhibition, which received considerable attention.

The first Convention arranged by the Sub-Committee took place in October, 1954, at John Wright Ltd., Birmingham, and proved to be highly successful.

Following this Convention, the next Group activity took the form of a visit to A.C.-Delco, Dunstable, and a film show on Materials Handling at Birmingham. A second Convention was held at Leamington Spa, in September, 1956, the theme being "Better Handling — Do It Now" and visits were paid to factories in the Midlands area which had introduced some significant development in materials handling. In addition to these visits, a Paper on "Materials Handling — Thorny Problems" was presented by Mr. John Bright, of Joseph Lucas Ltd. The Convention covered three days, and on the evening of the second day a series of films on Materials Handling was shown.

The Materials Handling Group, after its formation in 1957, organised a Convention in September of the same year, once again at Leamington Spa. This Convention made a slightly different approach to the subject in that visits were grouped under various headings and syndicate discussions were held to discuss, in detail, the visits made. A thought-provoking Paper was presented on "Mathematics of Handling" by Dr. K. D. Tocher, Research Applications Manager, United Steel Companies Ltd., which covered the field of Operational Research as it applies to Materials Handling. It is undoubtedly true to say that this subject will be of increasing importance in solving problems of material control.

When discussing the results of this Leamington Spa Convention, the Committee of the Materials Handling Group felt that its next national function, at Brighton, should be even more specific and should take the form of a working conference. It was thought that it would be of value to members to be presented with a clearly-defined, circumscribed materials handling problem in a given factory and that they should devote their entire time to the examination of this problem, to the analysis of its attendant factors, to the preparation of a report containing their conclusions, and to the presentation of their specific findings to the Convention as a whole.

The Committee were fortunate in finding a number of companies in Brighton and the surrounding district who were willing to co-operate by presenting a materials handling problem in their works for study by small groups of convention members. The spirit of ready co-operation of these companies, and the hospitality they extended to the members of the Convention, contributed materially to the success of this event which was held in September, 1958.

The syndicates, each comprising five or six members, worked enthusiastically right from the start, and the standard of team work in each syndicate was of a high order.

In addition to engineering firms, visits were paid to a brewery, and to furniture, clothing and chemical factories. The syndicate reports were presented within the framework of the four main groupings, these being :-

1. Problems of handling containers, cases and packages.
2. Problems of handling large articles for batch production.
3. Problems of handling small articles for batch and mass production.
4. Problems of handling induced by parts of awkward shapes.

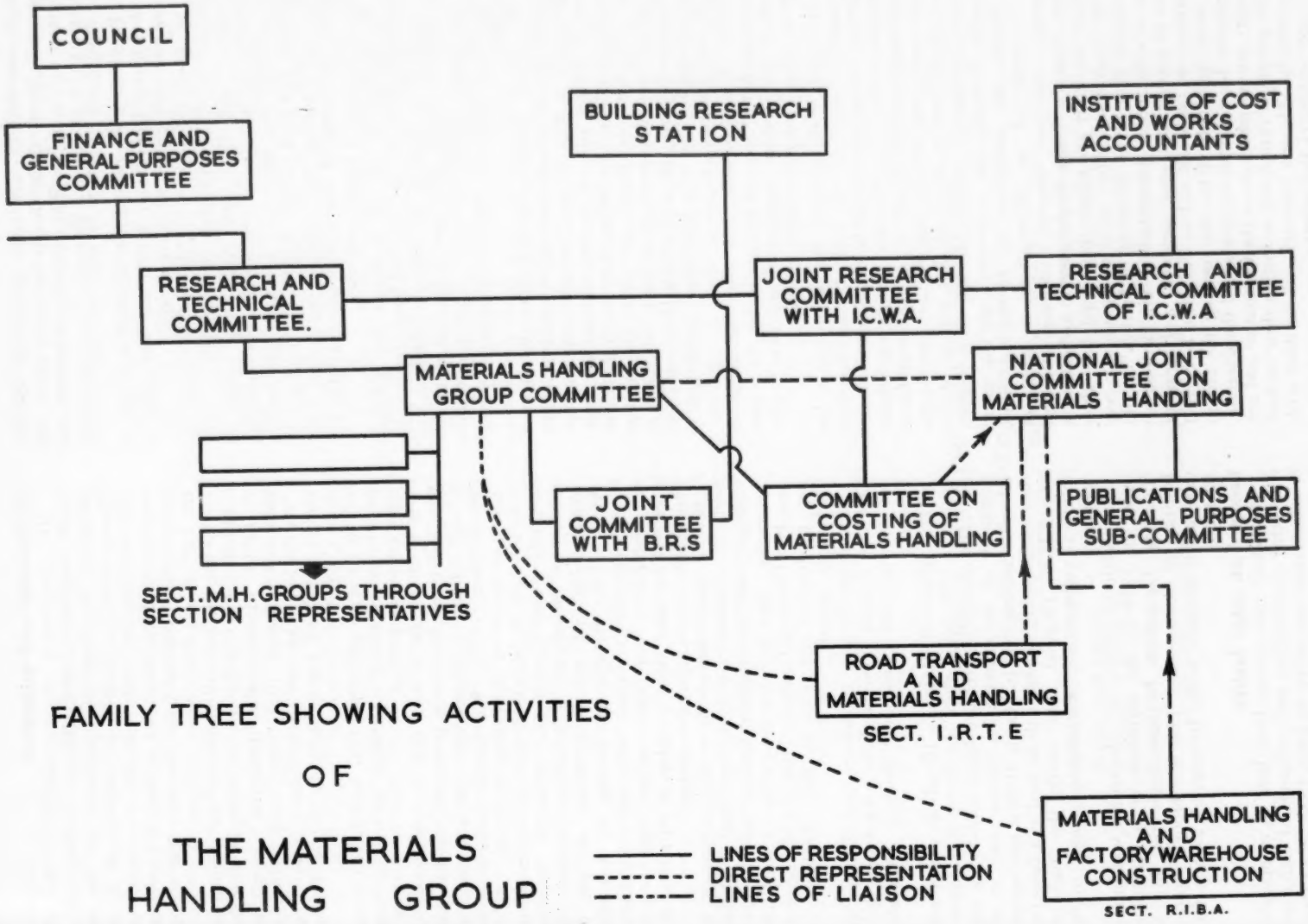
It was seen from the rapporteurs' observations and the syndicate reports that there was much constructive criticism of the manner in which the individual syndicates analysed their particular problem, and presented their conclusions. It was evident at the concluding session of the Convention that members agreed with the rapporteurs' observations and indeed, regarded these as being an equally valuable part of the proceedings as their own work.

It is interesting to note that not only was the conference of value to the delegates but also to the host firms, many of whom have written to the Committee to say that they valued the recommendations put forward by the delegates.

The latest venture of the Group was to organise for the Birmingham Section a special programme on the handling problems connected with "Building of the First British Motorway" and also "Handling into and through a Modern Motor Car Factory".

Section activities

Prior to the 1957 Convention, a meeting of the Section Representatives was called and discussion took place on how best the Group's terms of reference could be implemented. It was considered that initially Section Representatives would work within


COUNCIL
FINANCE AND GENERAL PURPOSES COMMITTEE
RESEARCH AND TECHNICAL COMMITTEE.
BUILDING RESEARCH STATION
INSTITUTE OF COST AND WORKS ACCOUNTANTS
JOINT RESEARCH COMMITTEE WITH I.C.W.A.
RESEARCH AND TECHNICAL COMMITTEE OF I.C.W.A
MATERIALS HANDLING GROUP COMMITTEE
NATIONAL JOINT COMMITTEE ON MATERIALS HANDLING
JOINT COMMITTEE WITH B.R.S
COMMITTEE ON COSTING OF MATERIALS HANDLING
PUBLICATIONS AND GENERAL PURPOSES SUB-COMMITTEE
SECT. M.H. GROUPS THROUGH SECTION REPRESENTATIVES
ROAD TRANSPORT AND MATERIALS HANDLING
SECT. I.R.T.E
MATERIALS HANDLING AND FACTORY WAREHOUSE CONSTRUCTION
SECT. R.I.B.A.
LINES OF RESPONSIBILITY
DIRECT REPRESENTATION
LINES OF LIAISON

FAMILY TREE SHOWING ACTIVITIES

OF

THE MATERIALS HANDLING GROUP

their own Sections, and build up activity with the general support of the Group. As a first step it was agreed that a list of films, synopses of lectures and abstracts of articles on Materials Handling would be circulated.

The second Representatives' meeting was held at the Brighton Convention, and it was interesting to note how some groups had progressed.

In Leeds, a group had decided to study the problem of "The Handling of Materials in Long Lengths" and visits were made to a variety of factories and warehouses in which this was a problem. In addition, film shows were arranged and Section meetings had been devoted entirely to the subject of Materials Handling. As a result of this project a full report was compiled and it is hoped that this will form the basis of a future conference.

In Manchester, Mr. H. C. Knott had achieved similar progress and meetings had been arranged bi-monthly at the firms of the different members, and in addition to film shows and a Section lecture on "Handling as an Aid to Export", a series of lectures had been organised at one of the local Technical Colleges.

Mr. G. A. Daniell reported from the Western Section that he had approached the problem slightly differently, in that he had contacted top management in several firms in his area to nominate someone to the group; care being taken to see that there was a majority of I.Prod.E. members. The Western Section Committee were particularly interested in "Packaging as an Aid to Materials Handling" and had arranged visits to a number of companies to study this problem.

Other Representatives had been successful in organising film shows and lectures within the framework of their Section programme, and were in process of stimulating more active interest.

As a result of this meeting, the Group Committee considered that much more leadership was necessary and more information should be circulated about the activities of the Group. As a first step several Section Representatives were invited to join the Group Committee and it was decided that Section Representatives should receive copies of that portion of the Group Committee's Minutes dealing with Section activities. Following this, a sub-committee was set up to discuss the promotion of Section activities. As a result of its deliberations a series of proposals was put forward, including, amongst others, that the Group should suggest to Sections a subject for study on which they could base their future programme. After some deliberation it was considered that "The Handling of Springs" would have a wide appeal, particularly if this covered all types of springs and small products, and terms of reference and proposals on how this could be carried out were circulated. Since this meeting the Group Committee have completely re-assessed the situation, brought new members on to the Committee and are in the process of completely re-casting their method of approach. This new approach will be dealt with in a later section of this report.

publications and education

To complement the conference at the 1952 Mechanical Handling Exhibition, a bibliography on Materials Handling was produced for the Sub-Committee by the Institution's Library staff. In 1958 this bibliography was completely revised and extended and was circulated to Section Representatives. A large number have also been sold through the Institution's Publications Department.

The first full scale publication of the original sub-committee was "A Review of Materials Handling in British Manufacturing Industries" which was published in August, 1952, being closely followed by "As the Spirit Moves", which was a series of case studies published jointly with the British Productivity Council.

The Proceedings of the 1957 and 1958 Conventions were published separately, as well as being reported in the Journal.

It is of interest to note that the proceedings of the 1957 Convention were presented, together with a large number of photographs specially taken for the occasion, at the 1958 annual meeting of the American Society of Mechanical Engineers.

In the field of education, the various committees felt that Plant Layout and Materials Handling should be introduced as a subject of study. In collaboration with Mr. T. B. Worth and Mr. G. Price, of the Birmingham College of Advanced Technology, the Committee submitted a syllabus to the Education Committee which was broadly accepted and now forms a subject in Part II in the Institution's new examination scheme.

Several short courses have been organised by Sections in conjunction with their local Technical Colleges, and Birmingham College of Advanced Technology have included the subject in their full-time Post Graduate Course in Principles of Engineering Production and also in their Diploma of Technology scheme.

Manchester College of Science and Technology have also recently introduced the subject into their two-year full-time course on "Machine Tools and Design".

The Institute of Materials Handling, which was formed in 1952, with which the Group is maintaining close contact, have also been considering the possibility of an examination scheme and at an informal meeting held in March, 1959, it was agreed that the I.Prod.E. syllabus will be used as a basis for any I.M.H. proposal, thus easing the load on technical colleges and encouraging courses to be organised.

An additional facility for information was introduced in 1959 by the aquisition of a Materials Handling Equipment Register from the British Institute of Management. This was brought up-to-date and is available in the Institution's Library for reference.

liaison with other bodies

The Group have always been keen to co-operate with other organisations and a channel of exchange of information was set up in June, 1957, by 15 professional Institutions and kindred associations. This

is known as the National Joint Committee on Materials Handling.

The purpose of the Joint Committee is to stimulate and co-ordinate the activities of the various bodies in relation to Materials Handling, and particularly with regard to education. Information is compiled and speakers exchanged, and the results of their many activities are disseminated among the members.

A recent development in the National Joint Committee is the setting up of specialist study groups to work on the following projects :-

(a) Materials Handling in relation to Factory Warehouse Construction;
(b) Road Transport Materials Handling;
(c) The Costing of Materials Handling.

The Institution is represented on the first two committees and the third is being organised through the Joint I.Prod.E./I.C.W.A. Research and Technical Committee. Individual Institutions are responsible for the secretariat of each of its study groups and report progress to the Joint Committee. The organisation chart on page 47 shows how these groups fit into the general pattern.

A particularly interesting study group was formed between the Group and the Building Research Station on the subject of "Co-operation between the Production Engineer and the Building Designer". The object of this exercise was to consider the level and extent of co-operation and co-ordination between them in the design and building of a new factory. In order to give the exercise reality a factory producing a range of mincing machines was envisaged, the production processes, flow charts, plant layouts, materials handling equipment necessary, etc., were considered, and the architects then designed a factory around this information. The lessons learned are at the present time being summarised and are due for publication within a few weeks.

conclusions and general trends of the Group

In the general introduction to this progress report of the Group's activities, it was mentioned that materials handling must be considered within the general field of production engineering. It is important to stress that the activities of the Group cover not only the techniques of handling, but also its effects on the broader concept of materials control; e.g., reduction of work in progress, simplified production control systems through improved handling, improved stores control and all the other factors which go to make up the work of the production engineer.

Consideration of the broader aspects opens up an exciting new field of activity for the production engineer, and with the enthusiastic support of its members it is certain that the Group will make its mark on the history of the Institution.

In achieving this end, it is likely that the Group will co-operate with other interested organisations, as well as with the other Sections of the Institution.

The Group Committee are certain that there are many members of the Institution pursuing problems in the field of materials handling and control who have a valuable contribution to make to the work of the Group, and who would welcome the opportunity of meeting fellow enthusiasts. If they would care to contact either a member of the Group Committee, their local Section Representative or a member of Head Office staff, they will be assured of every assistance. A list of Section Representatives is given overleaf.

MATERIALS HANDLING GROUP COMMITTEE

Chairman: F. E. RATTLIDGE, A.M.I.Prod.E.

Vice-Chairman: A. E. DUPREE, A.M.I.Prod.E.

G. M. RANSON, A.M.I.Prod.E.
G. PRICE, A.M.I.Prod.E.
D. H. GOSS, A.M.I.Prod.E.
L. HOEFKENS, A.I.Prod.E.
K. H. MATTHEWS, M.I.Prod.E.
R. C. SHORT, Grad.I.Prod.E.
P. A. BROADBENT, A.M.I.Prod.E.
W. J. PERKS, A.M.I.Prod.E.

All Section representatives are *ex officio* members of the Group Committee.

MATERIALS HANDLING GROUP

Section Representatives

Birmingham
B. H. Horton, A.M.I.Prod.E.,
40 Broad Road, Acocks Green, Birmingham, 27.

Birmingham Graduate
R. C. Short, Grad.I.Prod.E.,
41 Witherford Croft, Blossomfield, Solihull, Warwks.

Coventry
A. C. Evans, A.M.I.Prod.E.,
94 Hillmorton Road, Rugby.

Derby
D. H. Goss, A.M.I.Prod.E.
11 Inglesby Avenue, Derby.

Edinburgh
F. H. Eccersley, M.I.Prod.E.,
3 Queen Margaret Drive, Auchmurty, Glenrothes, Fife.

Glasgow
J. F. Gray, A.M.I.Prod.E.,
Philips Hamilton Works Ltd., Wellhall Road, Hamilton, Lanarkshire.

Leeds
W. M. Cunningham, A.M.I.Prod.E.,
Manager, Messrs. W. & T. Avery Ltd.,
Sherburn-in-Elmet, Nr. Leeds.

Leicester
H. J. Newton, M.I.Prod.E.,
Universal Conveyor Co. Ltd., Barkby Road, Leicester.

Liverpool
F. H. Booth, A.M.I.Prod.E.,
Vernons Industries Ltd., Kirkby Industrial Estate, Liverpool.

London
Change under consideration.

Luton
M. R. Barton, A.M.I.Prod.E.,
20 Burymead, Stevenage, Hertfordshire.

Manchester
S. Wright, M.I.Prod.E.,
11 Thorn Road, Bramhill, Cheshire.

Peterborough
W. Peck, M.I.Prod.E.,
7 Norfolk Street, Peterborough

Preston
H. S. Carelton, A.M.I.Prod.E.,
95 Liverpool Road South, Burscough, Lancashire.

Reading
H. P. Mott, M.I.Prod.E.,
Apple Trees, Burfield Common, Nr. Reading, Berks.

Sheffield
H. Steel, A.M.I.Prod.E.,
The Brightside Foundry and Engineering Co. Ltd.,
G.P.O. Box 118, Sheffield, 1.

Shrewsbury
W. Castledine, M.I.Prod.E.,
Croft, Bargates, Whitchurch, Shropshire.

South Essex
Change under consideration.

Stoke-on-Trent
D. Wood, Grad.I.Prod.E.,
A. G. Hayek and Partners Ltd., Federation House, Stoke-on-Trent.

Swansea
G. E. Halter, M.I.Prod.E.,
Leigh Beck, Charles Street, Skewen, Glamorgan.

Tees-side
T. H. Hall, M.I.Prod.E.,
Head Wrightson (Teesdale) Ltd., G.P.O. Box 10,
Teesdale Iron Works, Thornaby-on-Tees, Yorkshire.

Western
Change under consideration.

Wolverhampton
J. R. Allan, A.M.I.Prod.E.,
Blake House, Prestwood Road, Stourton,
Nr. Stourbridge, Worcester.

COUNCIL MEETING REPORT — continued from page 54

Liaison with Sections outside the United Kingdom

The Secretary, reporting on behalf of the Vice-Chairman of Council, Mr. R. H. S. Turner, who was in America, said that during the past quarter there had been a number of visitors to Headquarters from outside the U.K. A visit had been paid by Mr. Plint, of South Africa, and Mrs. Goyns, the wife of a Past President of the South African Council. Other visitors were Mr. Gupta, of the Bombay Section Committee; Mr. Goodchild, of Calcutta; Mr. Burley and Mr. Edwards, of Sydney; Mr. Cason, from Colombo; and Mr. Gwinnett, of Adelaide.

In addition, there had been correspondence with the Institution's officers overseas about matters arising from the last meeting of Council.

Certificates for Affiliated Organisations

It was recommended by the Finance and General Purposes Committee, and approved by the Council, that a Certificate of Affiliation be issued to organisations affiliated to the Institution.

Formation of Indian Council

Approval was given by the Council, on the recommendation of the Finance and General Purposes Committee, for the formation of an Indian Council. It was hoped that the Secretary would report further on this when he returned from his visit to India.

Obituary

The Council learned with great regret of the deaths of the following members:

Members: J. M. Wilson; W. H. Curtis.

Associate Members: G. E. Velge; J. R. Williams; W. Watson; T. B. Whitehouse; F. T. Palmer.

Date and Place of next Meeting

It was agreed that the next meeting of the Council should take place on Thursday, 28th January, 1960, at 11 a.m., at 10 Chesterfield Street, Mayfair, London, W.1.

Production Engineering Research Association of Great Britain

Quarterly Newsletter to the Institution

AT the recent Ninth General Assembly of the International Institution for Production Engineering Research (C.I.R.P.) held in Zurich, Dr. D. F. Galloway, Director of PERA, was elected President of the Institution in succession to Professor O. Kienzle, Technische Hochschule, Hanover. Professor Milton Shaw, of the Massachussets Institute of Technology, U.S.A., was elected Vice-President of the Institution.

Members of The Institution of Production Engineers will probably recall that C.I.R.P.'s Eighth General Assembly was held in Britain in September, 1958, when delegates from 14 countries were formally received and entertained to dinner by The Institution of Production Engineers at Leamington Spa.

The International Institution for Production Engineering Research was formed in 1949 - 1950 by the four founder members* in order to provide a common meeting ground for scientists investigating production engineering techniques and equipment in various countries. Production engineering research workers from 18 countries now report their findings to the Institution, which is thus playing an important part in the evolution of improved production techniques and equipment.

One of the Institution's main objectives is the removal of barriers to effective communication between production engineering research workers in all parts of the world, and at this year's Assembly it was agreed that a World Register of Production Engineering research should be compiled. The Assembly invited PERA to undertake the extensive work of translating, editing, classifying and disseminating all information to be incorporated in the Register. A complete World Register of production engineering research published in various languages will greatly reduce the risk of investigations being duplicated in different parts of the world, and will also greatly facilitate international communications between research workers.

Russian Engineering Journal

Convincing evidence of the rapid progress being made by Russians in the development of production techniques and many types of equipment and some consumer goods was obtained during the course of the recent visit to Russia by a PERA delegation comprising Dr. Galloway, the Research Manager and the Information Manager†. The high quality of Russian research and development on metal cutting and machine tools has also frequently been confirmed by reports published in "Machines and Tooling", PERA's cover-to-cover translation of "Stanki i Instrument", one of Russia's leading production journals. To assist industry in keeping abreast of important Russian developments over a much wider field of production than that covered by "Machines and Tooling", PERA is now publishing a cover-to-cover translation of another leading Russian technical journal "Vestnik Mashinostroeniya" under the title "Russian Engineering Journal".

* Dr. D. F. Galloway, Director of PERA.
Ingenieur General P. Nicolau, Director of the I.S.N.C.M. (France).
Professor E. Bickel, Ecole Polytechnique Federale de Zurich (Switzerland).
Professor O. Peters, Universite de Louvain (Belgium).

† Dr. Galloway reported on his impressions of the Soviet Union in The 1959 Sir Alfred Herbert Paper given to The Institution of Production Engineers, in London, on 10th December, 1959.

Press loads being determined during investigations into the PERA patented finish piercing technique which produces smooth, accurate punched holes without a shaving operation.

"Russian Engineering Journal" provides comprehensive coverage of production techniques and equipment, and also deals with the design and construction of many different types of equipment used in a wide range of industries. The reports published in "Russian Engineering Journal" are based on the researches of Russia's large and highly organised teams of scientists and engineers, who are backed by massive research facilities of the very highest quality. Critical surveys of the layout, organisation and control of complete Russian factories and of particular workshops are also published from time to time. Subjects discussed in recent issues of "Vestnik Mashinostroeniya" include the following:

PRODUCTION

Automatic Handling
Die Casting Machines
Non-electric Plating Process
Pneumatic Chucks
Precision Finishing of Holes by Ball Rolling
Mechanising Forging Processes
Pressure Casting
Electrolytic Polishing
High Frequency Metallisation
Causes of Grinding Cracks and Remedies
Plating Magnesium Alloys
Ultrasonics in Welding Operations
Electro-mechanical Working of Extra-hard Materials
Automation of Car Assembly
Ultrasonic Machining
Tapping Heat-resisting Materials
Construction of Hard Alloy (Cermet) Punches
Stresses in Cutting Tools

DESIGN AND CONSTRUCTION

Stresses in High Pressure Pipe Lines
Power Transmitted by Narrow Vee-belts
Mechanisms for Tipping Wagons
Axial Forces in Centrifugal Pumps
Design Trends in Bending and Straightening Machines
Effect of Lubrication on Bolted Joint Tightness
Aerodynamic Supports for High-speed Engines and Turbines
Cooling Rolling Bearings Operating at High Ambient Temperatures
Determining Axial Forces in Turbo-couplings
Calculating the Fatigue and Endurance of Machine Parts Under Variable Loading Conditions
Effect of Oil Viscosity and Quantity on Power Losses in Worm Gearing
Nomographs for the Calculation of Shaft Length
Babbitt Thicknesses for Slide Bearings

The subscription rates for "Russian Engineering Journal" are as follows:

	£	s.	d.
Ordinary rate within the U.K. (per annum)	8	0	0
Rate for Libraries of Educational Institutions within the U.K. (per annum)	5	12	0
Single copies within the U.K. ...		16	0

Further information can be obtained from:

The Information Manager,
Production Engineering Research Association,
Melton Mowbray, Leicestershire.

BINDERS FOR "THE PRODUCTION ENGINEER"

As a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six issues.

It will be found that copies of "The Production Engineer" can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference and handling of the volumes.

The new binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each.

REPORT OF THE MEETING OF COUNCIL

29th October, 1959

THE second Council meeting of the 1959 - 60 Session was held on Thursday, 29th October, 1959, at 10 Chesterfield Street, Mayfair, London, W.1. The Chairman of Council, Mr. H. W. Bowen, O.B.E., presided over an attendance of 30 members.

Before proceeding with the business of the meeting, the Chairman welcomed Mr. D. A. Bowman, Hon. Secretary of the Edinburgh Section; Mr. B. A. Green, Chairman of the Nottingham Section; and Mr. W. F. Reid, Hon. Secretary of the Southern Region.

Finance

The Council approved for presentation to the membership the audited accounts of the Institution for the year 1958 - 1959 (see pages 72 - 74 of this Journal.)

Secretary's Overseas Tour

It was reported that plans for the Secretary's tour were now complete. He would leave London on 12th January, and would first call on the Institution's Corresponding Member for the Middle East. He would then proceed to Bombay and Calcutta, and thence to Australia, where he would visit the Institution's Sections in Melbourne, Adelaide and Sydney. He would also attend the International Management Congress as a U.K. delegate.

From Australia, the Secretary would go to Johannesburg, to visit the South African Council, and possibly return through Bulawayo to establish contact with several members of the Institution in that part of Africa. He would return to London about the middle of April.

Schofield Travel Scholarship

It was reported that Mr. S. D. Hollander, this year's successful Scholar, had now settled down in the U.S.A. and was doing very well. The Council were reminded that the value of a Scholarship had now been increased from £250 to £500 per annum for the next three years.

Eastern Region Conference

The Secretary reported that this Conference, held in Norwich on 24th - 25th September, had attracted a good attendance in view of the thinly scattered membership in the area. It was interesting to note that most of those attending were top level executives. The Papers (which were published in the December, 1959 Journal) had been very well received and promoted some lively and interesting discussions.

Bibliography on The Effect of Technological Progress on Education

The Secretary reported that this publication had aroused widespread interest and congratulatory messages had been received at Head Office.

Education

It was reported by the Education Committee that their main work since the last Council Meeting had been consideration of exemptions of Commonwealth Universities and Technical Colleges, in connection with the Associate Membership Examination. The Practical Training Sub-Committee were continuing their work of preparing a report on the practical training requirements of the Instituiton.

Membership

The Council approved a number of applications for membership and transfer, details of which appear on pages 55 - 56 of this Journal.

The Journal

It was reported by the Editorial Committee that the printing contract with Maxwell, Love & Co. Ltd., due to expire in December, 1959, had been reviewed by the Committee, who had decided that it should be renewed for a further period of three years. It was noted that as a result of the settlement of the recent printing dispute, the Journal printing costs would be increased by 4% per annum — approximately £1,200.

The appearance of the Journal Supplement had been greatly improved by the incorporation of semi-displayed advertising for appointments, which was being well supported.

Institution Papers

The following report was received from the Papers Committee :

The 1959 E. W. Hancock Paper

The meeting at Bristol University on 12th October, 1959, when Mr. R. A. Banks, of I.C.I. Ltd., spoke on "Human Relations in Industry" attracted a

great deal of interest, and promoted a most stimulating discussion. Mr. Banks' address was recorded on the spot by the B.B.C. Mr. Harold Burke, Vice-President of the Institution, was in the Chair, and a full report of the proceedings appears on pages 2 - 16 of this Journal.

The 1959 Sir Alfred Herbert Paper

Plans were almost completed for the meeting at the Royal Institution, London, on 10th December, 1959, when Dr. Galloway, of PERA was to speak on "Production Engineering Developments in the Soviet Union".

The 1960 Sir Alfred Herbert Paper

Arrangements were well advanced for the presentation of this Paper by Professor R. E. Lane, of the Nuffield Department of Occupational Health, University of Manchester. His subject would be medical services in industry, and the meeting would now probably be held in London.

The 1960 Viscount Nuffield Paper

This Paper would be presented during the Institution's Summer Meeting on 27th June, 1960, and negotiations were in progress to obtain a first-class Paper on the part played by machine tool developmen in the national economy (*see Supplement to this Journal*).

The 1960 George Bray Memorial Lecture

This Paper would be presented by Mr. T. B. Philip, Technical Director of The Distillers Company Ltd., on production in bio-chemical engineering.

Conference Organising Committee

It was reported that the Conference Organising Committee set up by the Papers Committee, to make arrangements for a national conference on "Modern Trends in the Manipulation of Metals", at Brighton, in October, 1960, would also be concerned with the organisation of the Machine Tool Symposium at Cranfield, in August, 1960, as well as that part of the Summer Meeting dealing with the 1960 Viscount Nuffield Paper.

Programmes for these events had now been drafted and good progress was being made with the arrangements.

Research and Technical Committee

The following reports were received from the Research and Technical Committee on behalf of their Sub-Committees:

Materials Handling Group

The Group Committee were now taking steps to promote further Section activity by initiating a national project on "The Handling of Springs". The Study Group with the Building Research Station on "Co-ordination between the Production Engineer and the Building Designer" was nearing completion of its work. Continued support was being given to the various specialist study groups sponsored by the National Joint Committee on Materials Handling.

Control of Quality

The formation of a new Sub-Committee was being considered, to discuss ways and means of keeping the Institution in the forefront of this important subject. In addition, it would discuss the support which might be given by the Institution of the E.O.Q.C. Conference which was to be held in London, in 1960.

Co-ordination of Production Management Techniques

Steady progress was being made with this report.

Computers and Production Control

In order to speed up the work of the Committee, a number of new members were being co-opted.

Material Utilisation

The Sub-Committee's Report on "Improved Material Utilisation" was in the hands of the printers (*see leaflet issued with the Journal*).

Standardisation

It was reported by the Standards Committee that the Sub-Committee on International Standardisation were continuing their work of reading and preparing comments on the implementations of I.S.O. recommendations.

The Sub-Committee on Unit Heads and Platens, having thoroughly investigated the possibility of putting forward proposals on a standardised range of limit switches for machine tools, had found there was little demand for such a standard and consequently this matter had now been closed.

The Standard Committee continued their work of nominating representatives to B.S.I. Technical Committees, and in addition maintained active liaison with the National Joint Committee for Non-Destructive Testing, and the British Productivity Council.

The Library

The Chairman of the Library Committee reported that consideration had been given to the suggestion, made at a previous Council Meeting, that his Committee might undertake the preparation of a history of production engineering, as distinct from the history of the Institution. It had been decided to embark on a pilot project on production engineering development surrounding fractional horsepower motors, because this field comprised many different production engineering techniques and materials, and because the history of production engineering had been very greatly influenced by the emergence and development of the smaller electric motor. It was hoped to make a progress report to the Council at the next meeting.

Region and Section Quarterly Reports

The Council received a number of Quarterly Reports from Regions and Sections.

(*concluded on page* 50)

ELECTIONS AND TRANSFERS

29th October, 1959

ADELAIDE SECTION

Transfer
From Graduate to Associate Member
R S. Evans.

BIRMINGHAM SECTION

As Associate Members
G. M. Beardshaw; D. Townsend; R. E. Patience; A. E. Tomkins; G. R. Holmes; J. G. L. Betts.
As Graduates
H. J. Yeomans; C. P. Evans; P. D. Brown; A. K. Roy Choudhury; K. S. Strangward; G. A. J. Card; P. B. Fletcher; P. A. Briggs; R. E. Duncan; R. N. Ashton; J. Bailey; B. T. Wilkins; A. T. Yates; D. Hampson; C. H. Brown; J. C. Thompson; H. Prais; D. L. W. L. McWhirter; R. E. Butwell; G. W. Slimm; K. C. Ocraft; L. D. Jones; D. F. G. Denning; W. L. W. Stephenson; M. J. Lockley; M H. Bloomer; J. J. Eccles; A. M. Potter; I. J. Norton; M. A. Vaughan; P. B. Jayakumar; R. J. Mortiboys; B. H. Shilvock.
As Students
V. G. Haynes; J. S. Detheridge, A. J. Miles; J. T. Downing; J. W. Bragginton; R. G. Walker; D. Sheehan; B. Picton; R. J. Houston; A. G. Turley; N. M. Crane; C. L. Bowater; I. F. Campbell; R. C. Price; P. B. Sargent; E. F. Luton; K. M. Felton; M. D. Barrett; V. E. C. Crump; B. D. Phillips; T. B. Osborne.
Transfers
From Graduates to Associate Members
J. Rawicz-Szczerbo; J. P. Rochford; S. Hall.
From Students to Graduates
D. E. Aldridge; C. C. Blyth; W. C. Pearce; P. Telco; D. B. Austin; L. A. Hoefkens; R. A. Homer; B. B. Slater; J. E. Henson; J. W. Hands; R. A. Kendall; L. A. Griffiths.

BOMBAY SECTION

As Associate Member
P. V. R. Murthy.
As Graduates
V. S. R. Chandrashekhar; S. A. Inamdar; G. D. Sharma.
As Students
C. S. Raja; M. M. Ashraf.
Transfer
From Student to Graduate
J. Swarup.

CALCUTTA SECTION

As Associate Member
H. Mukherjee.
As Graduates
A. K. Dutt; P. K. Raychaudhuri; S. K. Mal; S. Shanmugam; C. S. Viswanathan.
Transfers
From Associate Member to Member
R. Mishra.
From Graduates to Associate Members
H. K. Mhatre; K. Vaidyanathan.

CANADA SECTION

As Associate Member
R. G. Mockler.

CARDIFF SECTION

As Graduates
P. I. Collier; G. H. Mabbett; D. G. Jones; W. G. Hall; A. McConkey; C. O'Neill; P. G. Smith; J. A. Evans.
As Students
M. Evans; J. T. Banfield; D. R. E. Derham; W. E. Gibbs; D. Havard; D. A. T. Long; E. T. Pitt; D. H. James; P. T. Herron; B. H. Jones; A. J. Davies; B. G. Moore; A. Morgan; M. Bullock; W. M. Ansell; W. A. Pearce; J. G. Harris; A. J. Davies; D. Hughes.
Transfers
From Students to Graduates
E. G. Bridges; W. G. Caddy; L. H. Parsons.

COVENTRY SECTION

As Associate Member
C. S. Horsley.
As Graduates
R. Hardy; B. A. Gaddal; W. M. J. Upton; R. C. New; K. C. Coleman; B. S. Hobson; R. E. Morgan; A. G. Hague; J. R. Morris; W. A. Richey; T. B. Forres; M. Bennett; R. P. King; M. H. Trahern; R. D. Bratt; C. Payne; J. I. Sundararaman; J. E. Page; J. E. Connor.
As Students
M. Stokes; E. B. Birch; C. A. Windsor; C. T. Wood.
Transfers
From Graduate to Associate Member
A. J. Sanders.
From Students to Graduates
P. H. Champion; J. R. Wildsmith; T. S. Evans.

CORNWALL SECTION

Transfer
From Associate Member to Member
J. F. Holman.

DERBY SECTION

As Graduates
R. Webster; S. A. Newberry; D. A. Horobin; H. Garner; J. F. Fisher; M. E. Hutchby; M. R. Walker; T. F. Roberts.
As Students
K. M. Peerless; D. W. Ryall; W. J. Milwain.
Transfer
From Student to Graduate
A. Phillips.

DONCASTER SECTION

As Graduates
M. Green; W. L. Kendall;

DUNDEE SECTION

As Graduates
R. T. M. Doughty; J. H. A. Mason; J. L. Millar.
As Student
R. Lindsay.
Transfers
From Students to Graduates
J. M. Brown; G. L. Fox; J. S. Bowman.

GLASGOW SECTION

As Member
D. Gair.
As Associate Members
J. M. Temple; A. Harvie; J. Henderson; C. Barnett.
As Graduates
G. Stewart; T. G. Ramsay; J. W. C. Hislop; W. P. McQuarrie; W. Wood; T. Finnigan; R. A. E. Haines; A. A. Mills; T. M. Millar; R. Lang; W. Robertson; J. M. Henderson; F. Howie; J. Mundie; R. P. Pringle.
As Students
R. S. Hayes; J. S. Maxwell; J. J. McGowan; T. Mullen; D. S. Ironside; H. M. Whitelaw; J. Ritchie; W. Cameron; A. MacR. Borland; W. Graham; J. C. McNeillie; D. Niven.
Transfers
From Graduates to Associate Members
W. Thomson; W J. Bell; J. Hunter.
From Students to Graduates
G. A. Leeper; T. G. G. Hyslop; E. Ward; S. Black.

GLOUCESTER SECTION

As Associate Members
R. C. M. Marshall; R. Harrison.
As Associate
L. J. G. Bayliss.
As Graduates
L. H. Baglin; P. F. Egan; M. G. Turner, A. Emery; S. H. Kite; D. Holmes.
Transfer
From Student to Graduate
M. O. Hickman.

HALIFAX & HUDDERSFIELD SECTION

As Student
M. A. Cooper.

IPSWICH & COLCHESTER SECTION

As Associate Member
M. P. Cecil.
As Associate
J. R. Parkinson.
As Graduate
J. A. Hosford.
As Student
P. J. Beard.

LEEDS SECTION

As Graduates
B. Marshall; G. L. Scothern; R. N. Walker; E. Smith; P. Jones; M. Smith; F. Race; D. A. Burridge.
As Students
M. I. E. Stathers; G. C. Spurr; J. D. Wood; M. E. Carter; T. Dawson; M. J. Margrave; B. A. Lee; R. Mullis.
Transfers
From Graduate to Associate Member
R. Rudolf.
From Student to Gradnate
P. Middleton.

LEICESTER SECTION

As Associate Members
K. Spenadel; V. A. Hollyoak.
As Graduates
P. Gould; B. D. J. Wildborne; E. J. Pratt; R. J. Bond; P. Broadhead; D. G. Weatherill; C. C. Fu; J. H. Roper.
As Student
G. Lindsay.
Transfers
From Graduates to Associate Members
R. Howard; C. R. Wosket; K. V. Gutteridge.
From Student to Graduate
R. E. Gulliver.

LINCOLN SECTION

As Graduates
W. Pearson; K. Popple.

LIVERPOOL SECTION

As Member
G. F. Lawson, O.B.E.
As Associate Members
S. Gibbins; E. F. Martin.
As Graduates
R. B. Shields; W. Jenkinson; C. F. Bethell; D. Brown; I. A. Blenkinsop; R. Hyde.
As Students
R. Roberts; P. J. Truesdale; M. Fearnley; B. Sixsmith; G. Colquitt; R. J. Onions; C. I. Eli.
Transfers
From Students to Graduates
J. L. Hignett; T. E. Drysdale; M. T. Brown; D. Beamer; R. O. Jones.

LONDON SECTION

As Associate Members
A. A. Lampard; A. C. Grace; G. J. Watson; A. A. Lankford; G. G. Thomas; W. A. C. Richards; E. D. Beaumont; S. D. Merrill; S. S. Mendelsson; R. B. McEwan.
As Associate
B. J. Vaidya.
As Graduates
D. F. Pratt; G. F. West; W. W. Sandys; B. W. Bristow; J. E. Porter; C. W. Chappell; J. G. Weaver; T. E. Grieves; J. F. Pugsley; P. A. Cook; P. R. Green; L. P. Greenhalgh; J. A. C. Lane; K. Seshadri; R. A. Bishop; K. B. Bunting; E. C. Arnold; T. J. Laverty; J. Scaife; R. H. Pritchard; A. H. Atkinson; D. Buckels; D. A. W. Boothe; A. C. Sibley; A. J. Barbasio; A. W. Kitson; P. A. Moyse; P. R. Johnson; R. W. Sparrow; H. P. Singh; F. N. White; R. D. Sweet; T. H. Bradstock;

J. J. Jones; J. A. Rowe; R. E. Stockbridge; S. C. Wendelken; D. S. Pedlar; A. H. Hunt; R. F. Levitt; D. R. Stephens; M. Blackman; J. J. W. Wallace; R. J. Reveley; A. G. Hawkins; R. W. Gravenor; J. E. Wakefield; P. G. Fearfield.

As Students

D. A. Nelhams; T. F. Perkins; S. B. Stubbs; K. G. Jackson; A. J. T. Smith; J. R. Smith; J. H. Duncan; R. J. Benson; P. D. Deathe; P. J. Convert; G. M. Webb; J. N. Warren; R. V. King; B. J. L. Watts; R. J. Hansford; W. R. Mead; N. M. Reed; J. Ganderton; R. Coupar; M. J. Saunders; P. J. Waters; R. J. Ellis; I. C. Whittaker; J. B. Tuttle; P. E. Montague; M. K. Miller; G. B. Grose; P. D. Toulouse; M. W. Rossiter; J. P. V. O'Regan; D. A. Ninnes; W. B. Palmer; D. Robinson; J. T. Stamp; M. S. Wright; C. B. Shore; A. P. Barber; B. G. Pizzey.

Transfers

From Associate Member to Member

W. C. Taylor.

From Graduates to Associate Members

D. J. Harris; F. R. Norris; H. C. Smith; T. Tebbutt; J. Davies; G. M. Vine; J. Cockell.

From Graduate to Associate

L. H. B. Williamson.

From Students to Graduates

J. C. Forward; B. B. Broughton; P. J. Solly; A. H. Meadows; C. J. Steele; M. H. Blake; J. G. Glover; R. C. Scott; V. G. Welham; P. J. Kenton; G. R. Simmons; D. J. W. Bindley; D. G. Bucknall; K. H. Williams.

LUTON SECTION

As Associate Members

D. P. Lant; T. Meldrum; M. P. Stevenson.

As Graduates

L. Smith; S. C. Shah; P. Cook; J. T. Hill; R. R. McGee; J. D. Tingle; J. S. Edwards; J. D. Wilson; F R. Gibbs; A. E. Dennis; A. R. Brown; R. E. Healey; A. T. Smith; R. W. Gibson; D. W. Alcock.

As Students

P. D. Nevard; W. G. Winder; A. C. Swain; B. Summerhayes; P. J. Coles; D. J. McLeod; M. K. Nethercott; C. Vyse; F. W. Kenzie; K. E. Nortrop; P. E. Prosser; R. H. Garrod; T. J. Pitcher; G E. Jones; R. S. Sutcliffe; W. A. Law; M Coates; J. M. O'Grady; D. J. Cook.

Transfers

From Students to Graduates

J. H. Kane; B. J. Smith; P. S. Howes; P. Hill.

MANCHESTER SECTION

As Associate Members

G. Jones; D. Brunnschweiler; A. Gibson.

As Graduates

C. Konar; A. Smith; A. K. Bandyopadhyay; F. D. Allen; M. Hiranya; W. K. Smith; G. Cumbes; P. J Higham; A. K. Dhar Roy; R. R. Davies; J. D. Brockes; E. V. Collings; A. J. P. Sabberwal; S. Sivasurbramanian; F. W. Brady; L. Simpson; E. Hartwell.

As Students

F. Thomasson; J. W. Touhey; B. J. Tweats; A. B. Burton; B. Head; A. E. Jordan; J. A. Rotherwell; D. Rowles; R. Sharples; J. Mycock; B. Stanley; P. G. McGreavy.

Transfers

From Graduates to Associate Members

A. S. Willcox; R. J. Aird; F. C. Summers, H. Smith.

From Students to Graduates

R. Turner; K. Mangnall; F. Hilton.

MELBOURNE SECTION

As Members

J. J. Strain; O. P. Yule.

NEWCASTLE UPON TYNE SECTION

As Associate Members

S. Poole; S. W. Herbert.

As Graduates

M. Grey; R. W. Hall; B. E. Nicod; A. B. Green

As Students

T. Bewsher; P. J. Knighton; A. Wright; R. Lamb.

Transfers

From Associate Member to Member

E. R. Silk.

From Graduate to Associate Member

J. L. Gillborn.

NORTHERN IRELAND SECTION

As Graduate

R. E. Sherman.

As Students

G. W. Taylor; W. K. Spence.

Transfers

From Associate Member to Member

E. W. Huggins.

From Graduates to Associate Members

K. Whitehead; B Booth.

NOTTINGHAM SECTION

As Associate Members

A. L. Swinn; D. F. Wrate; R. N. Mercer.

As Graduates

D. W. Pearce; B. Horsfield.

As Student

R. Walker.

Transfers

From Graduate to Associate Member

P. E. Guy.

From Students to Graduates

K. C. Smith; J. M. Forster; R. P. Paulson.

OXFORD SECTION

As Graduates

E. Matchett; J. J. Flynn.

As Students

A. M. Beckham; R. A. Gardner.

PETERBOROUGH SECTION

As Graduate

A. B. Ratcliffe.

Transfers

From Graduate to Associate Member

D. St. A. Hunt.

From Student to Graduate

J. M. Barnes.

PRESTON SECTION

As Graduates

F. H. Vinten; J. Heywood; D. J. Alderson; D. Rushton; M. Robinson; R. Worsley; R. N. M. Parkinson.

As Students

J. Roberts; E. H. Busby; H. A. Brown; R. Brookes; F. Gee; V. Crane.

Transfers

From Graduate to Associate Member

K. E. Mullen.

From Students to Graduates

K. P. Wheeler; A. Leach; K. W. Topliss.

READING SECTION

As Associate Members

P. B. Belcher; E. H. Morland-Jee; T. S. Aram.

As Graduates

A. G. Dowding; O. L. Rigby; R. Parsons; L. J. Telling.

As Students

L. F. Sargeant; D. K. Stone; G. R. W. Barrows; M. C. Embleton.

Transfers

From Associate Member to Member

C. A. Forse.

From Graduate to Associate Member

D. W. Pickston

From Students to Graduates

A. R. Stephenson; M. T. Parsons; A. D. Randall.

ROCHESTER SECTION

As Graduates

J. P. Smith; J. A. Rogers.

Transfer

From Student to Graduate

R. A. Vane.

SHEFFIELD SECTION

As Members

E. A. Morrison (Re-instatement); M. A. Alexander.

As Associate Member

T. Doherty.

As Graduate

J. Roberts.

As Students

J. Hoyland; J. A. Idell; P. L. Sheldon.

Transfers

From Associate Member to Member

W. G. A. Jenkins.

From Students to Graduates

A. Matthews; P Brown.

SHREWSBURY SECTION

As Student

J. N. Tudor.

SOUTHAMPTON SECTION

As Associate Members

E. D. Ikin; J. A. West.

As Graduates

J. E. Ralph; B. E. F. Granger; H. V. Nicol; M. C. Taplin; V. C. W. Silvester; D. Lake; W. J. Lucas; J. Walmsley.

As Student

C. L. H. Prudon.

Transfer

From Student to Graduate

F. A. P. Martin.

SOUTH AFRICA SECTION

As Associate Member

F. J. Rawbone; V. L. Thomas.

As Graduate

S. Lees.

As Student

L. E. Curtis.

SOUTH ESSEX SECTION

As Associate Members

H. V. Gisby; A. D. Caulfield; H. Kauders; E. F. Cox.

As Graduates

N. M. Powell; D. N. Walker; G. E. Ewins; P. C. J. Horsnell; V. Wingfield-Smith; B. S. Bovington; R. Hatcliffe; J. M. Crabtree; P. O'Gorman.

As Students

P. R. Launder; R. C. Dicks; P. J. Wheal; R. P. Knowles; D. J. Finch.

Transfer

From Student to Graduate

D. W. Gilson.

STOKE-ON-TRENT SECTION

As Associate Member

G. H. Webb.

As Graduates

M. T. Rushton; G. C. Maxfield; F. J. Leese.

As Students

M. H. Smith; J. Wright; J. D. Alton; R. C. Stubbs; G. M. Berks.

SWANSEA SECTION

As Graduates

D. M. Lewis-Williams; B. D. O. Edwards.

TEES-SIDE SECTION

As Associate Members

P. Bonner; C. Kell.

As Associate

S. J. Overend.

WESTERN SECTION

As Graduates

K. J. Watts; D. G. N. Vasey; R. L. Ellis; D. H. Hutt; J. Heal; W. A. Acott.

As Students

R. E. Hopkins; R. A. Perrett; P. H. Wells; P. N. Blake; B. Redman.

Transfers

From Associate Member to Member

D. Liptrot.

From Students to Graduates

D. J. Watts; J. W. Duggleby; J. D. Beckett; A. J. Jones; E. A. Reddicliffe.

WOLVERHAMPTON SECTION

As Associate Members

R. J. Hazlehurst; M. A. Pound.

As Graduates

D. C. Ragdale; A. E. Johns; D. A. Heayel; E. Hayes; G. Hill; D. J. Kind; K. Slaney; J. N. Lane; R. A. Duckers; R. Wheatley; J L. Ryder.

As Students

G. Holt; A. M. McCumiskey; W. J. Heap; L. N. Hopkins; P. Darnley; R. L. Richards; I. H. Cotton; P. M. Swindon; F. W. Lock; S. A. Bhimjee; D. Westwood; D. J. Howell; P. R. Toft; D. J. Barrett.

Transfers

From Students to Graduates

A. J. Braddock; J. R. Winchurch; K. B. Nicholls.

WORCESTER SECTION

As Associate Member

G. J. Jones.

As Graduates

R. Clarke; B. J. D. Nicklin.

As Students

G. D. Jirak; M. Sundaram.

NO SECTION

As Associate Members

D. Solman; R. J. Bridge.

As Graduates

S. Safiruddin; M. Shuja-Ud-Din Khan.

Transfer

From Student to Graduate

A. Haleem.

WALES REGION — INAUGURAL DINNER

The Inaugural Dinner organised by the Wales Region, and held in the Banqueting Hall of Cardiff Castle on 6th November last, was a most successful and enjoyable occasion. Mr. H. G. H. Dixon, Chairman of the Wales Region and the Cardiff Section, presided.

The Region were pleased to welcome, in addition to the principal guest speaker, Professor O'Neill, of The University of Swansea; the Lord Mayor of Cardiff (Alderman Mrs. Helena Evans, J.P.); the President of the Institution, Mr. G. Ronald Pryor; the Chairman of Council, Mr. H. W. Bowen, O.B.E.; and the Institution Secretary, Mr. W. F. S. Woodford.

In proposing the toast of "The Institution", Professor O'Neill stressed the need for more lectures in the more advanced technological fields. He also referred to the tremendous responsibilities facing both the Government and industry in meeting the challenge of the "bulge" years in the employment of young people. The President, Mr. Pryor, who responded on behalf of the Institution, gave details of the work being done by the Institution in the educational field.

Mr. J. Hopkinson, Chairman of the Swansea Section, proposed the toast to "The Guests", to which the Lord Mayor of Cardiff responded. She emphasised the importance of the production engineer to Wales, where the pattern of industry has been rapidly changing from heavy to light engineering, and commented on the increasing competition from Russia and other Iron Curtain countries, which she had recently visited.

The evening concluded with a conducted tour of Cardiff Castle.

SCHOFIELD TRAVEL SCHOLARSHIPS, 1960

Special announcement to all Graduate members of the Institution within the United Kingdom

The Schofield Travel Scholarships are among the most valuable awards open to students of engineering. They offer to ambitious Graduate members of The Institution of Production Engineers opportunities to obtain, in other countries, experience both of production technology and human relations, which will be of great value in their future careers.

The Schofield Travel Scholarship is of the value of £500 per award, or in special cases up to £750.

Forms of application and full details are obtainable from the Registrar of the Institution, and applications for this year's award must be received by 1st March, 1960.

NEW ADDRESSING EQUIPMENT

Consequent upon new addressing equipment being installed at Head Office, new address plates have had to be made.

Members are asked carefully to note the name and address on any correspondence received from Head Office, including Journal envelopes, and to inform the Secretary at once if there is any discrepancy.

Professor O'Neill (centre), of The University of Swansea, principal guest speaker at the Wales Regional Dinner, with (left) the Chairman of Council, Mr. H. W. Bowen, O.B.E.; and (right) Mr. W. H. Bowman, Past Regional Chairman.

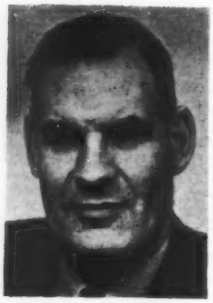
Included in this photograph, taken at Cardiff Castle, are Mr. H. G. H. Dixon (extreme right), Chairman of the Wales Region and of the Cardiff Section; the President of the Institution, Mr. G. Ronald Pryor; and (extreme left) the Institution Secretary, Mr. W. F. S. Woodford.

(Both these photographs were taken by Mr. W. J. Ford, of the Cardiff Section Committee)

NEWS OF MEMBERS

Mr. F. Bloor, Member, Vice-Principal and Head of the Engineering Department, Farnborough Technical College, has been appointed Principal Designate of the new Eastleigh Technical College.

Mr. Bernard Boxall, Member, has resigned his directorships with Production Engineering Ltd., and Combined Technical Services Ltd., and is now operating independently as a Management Consultant. Mr. Boxall is still retaining the directorships of Bookers Engineering Holdings Ltd., George Fletcher and Co. Ltd., Reliance Manufacturing Co. (Southwark) Ltd. — Chairman ; Scottish Aviation Ltd. — Deputy Chairman ; Export Packing Service Ltd.



Mr. F. E. V. Spence, Member, has been appointed Managing Director of Lodge Plugs Ltd., Rugby. He was formerly Works Director.

Mr. T. L. Booth, Associate Member, previously Director and General Manager of Hepworth & Grandage (Yeadon) Ltd., has been appointed to the Board of the Hepworth & Grandage Ltd., parent Company and has now moved to their St. John's factory at Bradford. Mr. Booth remains on the Board of Hepworth & Grandage (Yeadon) Ltd.

Mr. L. J. Daughtrey, Associate Member, has been transferred to the Atomic Energy Authority's station at Foulness. Mr. Daughtrey was formerly Hon. Secretary of the Institution's Reading Section.

Mr. S. Davey, Associate Member, has now taken over as Chief Engineer, Reactors and Diffusion Plants in the Engineering Group of the Production Branch, with the United Kingdom Atomic Energy Authority.

Mr. R. A. Foley, Associate Member, has been transferred from Production Engineer with the Camden Street Group of Wilmot Breeden Ltd., to a similar position with Telehoist Ltd. (a Wilmot Breeden Company) Cheltenham.

Mr. W. E. Fowler, Associate Member, has taken up an appointment with the Gloucester Education Committee and is now teaching Metalwork and Engineering in Gloucester.

Mr. W. H. Holmes, Associate Member, has relinquished his position as Management Consultant with Associated Industrial Consultants Ltd., and has taken up a new appointment with M.T.E. Control Gear Ltd., in the capacity of Joint Managing Director.

Mr. D. R. B. Hope, Associate Member, has been appointed Production Engineer with Westclox Ltd., Strathleven, Dumbarton.

Mr. A. H. Macbeth, Associate Member, has recently relinquished his position as Joint Managing Director of Surplice & Tozer Engineering Co. Ltd.

Mr. W. T. Neill, M.B.E., Associate Member, has recently been appointed Managing Director of Platt Brothers & Co. Ltd., Hartford Works, Oldham, Lancashire. Mr. Neill was previously with De Havilland Propellers Ltd., Lostock, near Bolton, as Deputy General Manager, and joined Platt Brothers as Works Director and General Manager in April, 1958.

Mr. J. A. Thomas, Associate Member, has relinquished his position with Joseph Sankey & Sons Ltd., Bilston, and has taken up an appointment as Engineering Sales Manager at Joseph Sankey & Sons (Manor Works) Ltd., Wolverhampton.

Mr. E. Scott, Associate Member, formerly Production Manager, has been appointed General Works Manager and Deputy General Manager of the Engine, Gear Box and Axle Divisions of The Rover Company Ltd.

Mr. J. E. Weatherley, Associate Member, has taken up an appointment as Chief Production Engineer to Kenwood Manufacturing Company Ltd., Woking, Surrey.

Mr. B. Whittaker, Associate Member, is joining the Board of Turner Bros. (Birmingham) Ltd., Birmingham, as Works Director.

Mr. A. A. Goldring, Graduate, is now with H. A. Simons Limited, Consulting Engineers, Vancouver, B.C., Canada.

Mr. J. B. Hodges, Graduate, has recently left England to install equipment and initiate production for Joseph Lucas Ltd., in Madras, India.

Mr. E. Hollingworth, Graduate, has relinquished his position as Senior Mechanical Development Engineer with The General Electric Company Ltd., Osram Lamp Works, Shaw Factory, and has taken up a position as Chief Engineer with Edward Yates & Sons Ltd., Marple, Cheshire.

Mr. I. W. Readman, Graduate, has relinquished his position with W. & T. Avery Ltd., in order to take up an appointment as Production Manager, Aircraft, with the Triplex Safety Glass Co. Ltd., Kings Norton, Birmingham.

Mr. K. Seshadri, Graduate, has taken up a position at Lockheed Hydraulic Brake Co. Ltd., Leamington Spa, as Senior Jig and Tool Designer.

Mr. P. Spence-Brown, Graduate, has recently been appointed Work Study Officer to the Harlow Metal Co. Ltd., Harlow, Essex.

Obituary

The Institution regrets to record the death of **Mr. K. W. Tatchell,** Associate Member, of the Melbourne Section. Mr. Tatchell, who was Principal of Collingwood Technical School and Deputy Chairman of the Apprenticeship Commission of Victoria, was formerly Chief Inspector of Technical Schools in Victoria.

During 17 years in industry and 22 years in the educational field, he played a major part in the initiation and development of the Melbourne Section of the Institution, and the establishment in Victoria of courses in production engineering.

DIARY DATES FOR 1960

March 17th ... ... **The 1959 Viscount Nuffield Paper,** at the Rankine Hall, Institute of Engineers and Shipbuilders in Scotland, Glasgow.
Speaker: **Dr. C. Timms,** M.I.Prod.E., National Engineering Laboratory.
Subject: **"Recent Developments in Spur and Helical Gears."**

May 11th ... ... **Sixth Conference of Engineers Responsible for Standards,** at the Connaught Rooms, London.

June 27th ... ... **Summer Meeting** and **The 1960 Viscount Nuffield Paper,** at the Festival Hall, London.

August 24th - 28th ... ... **Summer School,** at The College of Aeronautics, Cranfield.
Theme: **"Control of Cutting Processes."**

October 19th - 22nd ... **National Conference,** at Brighton.
Theme: **"Modern Trends in the Manipulation of Metals."**

NOTICE OF ANNUAL GENERAL MEETING

NOTICE is hereby given that the Annual General Meeting of the Institution will be held at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 28th January, 1960, at 2 p.m.

AGENDA

1. Notice convening Meeting.
2. Minutes of the Annual General Meeting held on 29th January, 1959.
3. Minutes of the Extraordinary General Meeting held on 30th April, 1959.
4. Report on Election of Members to Council 1.
5. Annual Report of Council 2.
6. Presentation of Statement on Income and Expenditure, Balance Sheet and Auditors' Report 3.
7. Election of Auditors, 1959 - 1960.
8. Election of Solicitors, 1959 - 1960.
9. Votes of Thanks.

By Order of the Council.
W. F. S. WOODFORD, *Secretary.*

1. See page 63. 2. See page 64 3. See page 72.

MINUTES OF ANNUAL GENERAL MEETING

held on 29th January, 1959

THE Annual General Meeting of the Institution was held at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 29th January, 1959, at 2 p.m.

The Rt. Hon. the Earl of Halsbury, F.R.I.C., F.Inst.P., President, was in the Chair.

Notice convening Meeting

The Secretary (Mr. W. F. S. Woodford) read the Notice convening the meeting.

Minutes of Extraordinary General Meeting held on 30th January, 1958.

The Minutes of the Extraordinary General Meeting held on 30th January, 1958, which had been circulated, were taken as read and were confirmed and signed as correct.

Minutes of the Annual General Meeting held on 30th January, 1958

The Minutes of the Annual General Meeting held on 30th January, 1958, which had been circulated, were taken as read and were confirmed and signed as correct.

Report on Election of Members to Council

The Report on the Election of Members to Council was received on the motion of the President, seconded by Mr. R. H. S. Turner.

Annual Report of Council

Mr. H. W. Bowen, Chairman of Council, said that the Report of Council was to be found on pages 42 - 48 of the January, 1959 Journal, and he formally moved its adoption.

Mr. E. Percy Edwards seconded the motion which was *carried.*

Statement on Income and Expenditure, Balance Sheet and Auditors' Report

Mr. H. W. Bowen (Chairman of Council) moved the adoption of the accounts.

Mr. G. R. Blakely seconded, and there being no questions arising from the income and expenditure statement, balance sheet and auditors' report the motion was put to the meeting and *carried unanimously.*

Royal Charter of Incorporation

Mr. E. F. Gilberthorpe moved that the Institution should petition Her Majesty The Queen for a grant of a Royal Charter of Incorporation, and that the Council be empowered to take all necessary action.

Mr. J. H. Winskill seconded the motion which was *carried unanimously.*

Election of Auditors

On the motion of Mr. G. R. Pryor, seconded by Mr. R. E. Mills, Messrs. Gibson, Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution for the year 1958 - 1959 and were thanked for their previous services.

Election of Solicitors

On the motion of Mr. K. J. Hume, seconded by Mr. S. G. E. Nash, Messrs. Syrett & Sons were appointed Solicitors to the Institution for the year 1958 - 1959 and were thanked for their previous services.

It was also unanimously agreed that a message of sympathy and best wishes for a speedy recovery should be conveyed to Mr. Herbert Syrett, the senior partner of Messrs. Syrett & Sons, who was seriously ill.

Votes of Thanks

The President moved a hearty vote of thanks to all those whose work had helped to make the Institution's affairs a success in the past year. First he desired to mention all the Region and Section Officers who were too numerous to name. Then there was the Chairman of Council, Mr. Bowen, and the Vice-Chairman, Mr. Turner, both of whom had executive work to do on behalf of the Institution which, needless to say, they had discharged throughout the year to everyone's entire satisfaction and with their usual conscientiousness.

Council would wish him to include for special mention the Chairmen of the Standing Committees, who gave most generously of their time during the course of the year, and all members of the Institution who had helped in one way or another.

Lastly, of course, Members of Council would wish to include in the vote of thanks the servants of the Institution, principally the Secretary, Mr. Woodford, and his staff, whose labours in the interests of the Institution had done very much to promote the welfare and prosperity of the Institution during the year just ended.

Mr. H. P. Mott seconded the vote of thanks, which was *carried unanimously with acclamation.*

Mr. H. W. Bowen moved a vote of thanks to the President for the excellent work which he had done. Of all the excellent Presidents which the Institution had enjoyed, none had been better than Lord Halsbury.

A vote of thanks was due to the President not only for having presided over the meetings of Council during the year, but also for the excellent work which he had done for the Institution generally.

The vote of thanks was carried by acclamation.

The President, in response, said it had been a pleasure to serve the Institution as President.

The meeting then terminated.

MINUTES OF EXTRAORDINARY GENERAL MEETING

held on 30th April, 1959

THE CHAIRMAN (Mr. G. Ronald Pryor) apologised for the absence of the President, Lord Halsbury, who should have been in the Chair.

Memorandum of Association of the Institution

Mr. R. J. C. WHITAKER moved:

"That the Memorandum of Association of the Institution be altered in accordance with the terms printed in the Notice of the Meeting."

Mr. L. W. BAILEY seconded.

Mr. GORDON ENGLAND congratulated the Council on a magnificent piece of work. He thought all the documents presented were a first-class effort.

The motion was carried nem con.

Articles of Association

The CHAIRMAN explained that it was essential when petitioning for a Royal Charter that the draft Charter should be substantially the same as the existing Memorandum of Association, and that the draft Bye-Laws be substantially the same as the Articles of Association. Therefore, it was necessary to obtain the meeting's approval of the proposed alterations.

Mr. R. N. MARLAND moved :

"That the Articles of Association of the Institution be altered in accordance with the terms printed in the Notice of the Meeting subject to the correction of certain misprints which had been enumerated."

Mr. J. L. GWYTHER seconded.

The motion was carried nem con.

Petitioners

The CHAIRMAN explained that Council considered it desirable that the Petition should be signed by the Past Presidents of the Institution, and those set out were the Past Presidents who were available and who had agreed to sign the Petition.

Mr. A. L. STUCHBERY moved in accordance with the terms printed in the Notice of the Meeting :

"That the Petitioners therein named (being members of the Council of the Institution) be authorised and requested to present on behalf of the Institution and its members the Petition submitted to this Meeting praying that Her Majesty may be graciously pleased to grant a Charter of Incorporation to incorporate a company incorporated by Her Majesty's Royal Charter to acquire and take over the assets and carry on the activities of the Institution in succession to the present Limited Company."

Mr. B. C. HARRISON seconded.

The motion was carried nem con.

Subscriptions

Mr. H. W. BOWEN (Chairman of Council) said that when the subscriptions were last increased, the Council took the view that membership subscriptions should not be more than absolutely necessary, since the anticipation of inflation was the main cause of inflation. However, the subsequent events proved that the Council's policy, although patriotic, was not in the best interests of the Institution. Within 12 months the Postmaster General increased postage and telephone rates, which absorbed almost the whole of the additional income.

The Institution in the United Kingdom was just making both ends meet with a very small margin, and the Council felt that that was not a business-like way to run the Institution, since it made no provision for the growth and expansion of the profession. It was the view of the Council and its Finance and General Purposes Committee that the Institution should budget annually for an excess of income over expenditure of a minimum of 10% of income, and the new subscription rates had been calculated to produce that additional revenue.

He accordingly moved :

"That with effect from 1st July, 1959, the entrance fees and annual membership subscriptions should be increased in accordance with the terms printed in the Notice of the Meeting."

Mr. J. V. CONNOLLY seconded, stating that it was not in his view possible to run with any greater economy within the Institution that at present, because the budgetary control of finance and economy within the Institution compared more than favourably with any other he had ever seen.

Mr. R. H. S. TURNER said that the Institution had been in contact with its members overseas regarding their feelings with respect to the proposed increases in subscription, and the first matter which came up was that any relief in income tax was not applicable to overseas members. Therefore there was no softening of the blow as far as they were concerned. Secondly, in many instances the increase would mean that those members were paying a subscription which was in excess of that

payable to other comparable Institutions overseas. Thirdly, many of the overseas members lived in scattered and widely distributed areas where they were not able to participate in the functions and amenities of an Institution such as the I.Prod.E.; therefore in his view those members should receive special consideration, primarily in view of the income tax position.

Therefore, he moved as an amendment :-

"provided that the increases in entrance fees and annual subscriptions shall not apply to members outside the United Kingdom until such time as Council shall direct."

Mr. H. P. MOTT seconded.

The amendment was carried nem con.

The motion as amended was carried nem con.

Mr. H. P. MOTT moved :

"That this Meeting approves the draft Charter and Bye-Laws submitted to the meeting."

Mr. TAYLOR seconded.

The motion was carried nem con.

Mr. K. J. HUME moved in accordance with the terms printed in the Notice of the Meeting :

"That in the event of Her Majesty being graciously pleased to comply with the prayer to the said Petition a further Extraordinary General Meeting of the Institution shall forthwith be convened to pass Special Resolutions for the winding up of the Institution and for all the transfer of all the property of the Institution after satisfaction of all its debts and liabilities to the new corporation which will have been incorporated by Her Majesty's Charter."

Mr. NICOLSON LOW seconded.

The motion was carried nem con.

That concluded the business of the Extraordinary General Meeting, and the Chairman declared the proceedings terminated.

REPORT ON ELECTION OF MEMBERS TO COUNCIL

IN accordance with Article of Association No. 34, there were nine vacancies for elected Members of Council (eight Members and one Associate Member).

For the eight vacancies for elected Members 15 nominations were received. As a result of the ballot conducted in accordance with Article of Association No. 43, the following were elected :-

Mr. C. T. Butler
Dr. N. A. Dudley
Mr. B. H. Dyson
Mr. J. France
Mr. S. G. E. Nash
Mr. J. S. Silver
Mr. H. Unsworth
Mr. G. A. J. Witton

For the one vacancy for the elected Associate Member, four nominations were received. The Associate Member elected was :-

Mr. R. S. Clark

Ballot Papers were circulated to 6,059 Corporate Members in the United Kingdom. Details of voting issued by the Institution's Auditors are as follows :-

Eligible papers included in the ballot		1,183
Rejected :		
Incorrect number of votes ...	30	
Papers not marked in ink ...	10	
Spoiled papers	6	
Envelopes unsealed	5	
Insufficiently stamped — not accepted	22	
Received from G.P.O.— addressees not traced	6	
Papers received after closing date	49	
Correspondence received with Ballot Papers	2	
	—	130
		1,313

The full list of Council Members for the current year is published in the Journal.

REPORT OF COUNCIL

1st July, 1958 to 30th June, 1959

to be presented by the Chairman of Council

at the Annual General Meeting, Thursday, 28th January, 1960

THIS past year has been a very important one for the Council, who have been called upon to make a number of major decisions which may well have a very far reaching effect on the future of our Institution. In presenting this Report on behalf of all my colleagues not only on the Council, but on the Standing Committees to whom such a lot of our routine work is delegated, I should like to express my gratitude to all of them for their loyal support which they have given me as Chairman throughout the year.

the Charter petition

By far the most dominant step we took during the year was the placing before Her Majesty the Queen of a Petition for the grant of a Royal Charter of Incorporation for the Institution. The preparations for the major decision have been going on for some considerable time past, and have caused your Council a very great deal of consideration and heart searching. We had first to feel certain that the Institution's work and achievements had reached the stage when we felt, in all humility, that we could petition Her Majesty. Even supposing that we felt our case was good, we had to decide whether or not this was the best time. We received tremendous help in this from the President, the Rt. Hon. the Earl of Halsbury, whose advice and guidance were of inestimable value. The final decision was made at an Extraordinary General Meeting of the members held on 30th April, 1959, when the members attending approved the terms of the draft Petition and draft Charter and Bye-laws and authorised your Council to proceed.

The preparatory work had been entrusted to a special sub-committee comprised of Lord Halsbury, the President; Mr. Ronald Pryor, President-Elect; Mr. Harry Gregory, Immediate Past Chairman of Council; and myself as Chairman of Council for the time being. I should like at this stage to pay a particular tribute to Mr. Pryor who, with single-mindedness of purpose has been pursuing this object on our behalf for several years past, aided at all times by the Secretariat who have been indefatigable in gathering together all the information which the special committee needed. The Petition was duly lodged on our behalf by our Solicitors, Messrs. Syrett & Sons. After a short passage of time, we were informed that only one objection to our Petition had been made and for this we had been partly prepared. Lord Halsbury's sub-committee again spent many hours considering the points raised in the objection and preparing our reply. Our reply was forwarded to the Privy Council in November, 1959, and we must contain ourselves in patience until Her Majesty's pleasure is made known to us.

increase in subscriptions

Another tremendously important decision which the Council were called upon to make was the increase in the rates of our annual subscriptions. Your Council's proposals were made known to the membership at the Extraordinary General Meeting held on 30th April, 1959. Arising from the extensive discussions brought about by the Charter Petition and the increase in subscriptions, your Council decided that the time was ripe to make another survey of the Institution's organisation and structure.

You will remember that, in 1951, the special committee under the Chairmanship of Mr. Harold Burke made a detailed study of the whole of the organisation and administration of the Institution and reported thereon to the Council. Almost all the recommendations in what is now known as the Burke Report, were adopted and put into effect. Your Council felt, therefore, that the terms of reference for this new survey should be: "To review the implementations of the recommendations contained in the Report of the Committee on Organisation dated 1951, as modified by the Council; to consider their effectiveness and to make recommendations". Mr. R. H. S. Turner, the Vice-Chairman of Council, was appointed Chairman of this *Ad Hoc* Committee and each of the Regions was invited to nominate a representative. The following members served on the Committee. *Principal Officers*: Lord Halsbury;

G. Ronald Pryor; J. E. Hill; H. W. Bowen; R. H. S. Turner. *Members*: W. H. Bowman; R. S. Brown (alternate S.G.E. Nash); H. Tomlinson; H. Crompton; K. S. Jewson; A. S. Johnstone; H. P. Mott; R. Telford; R. S. Clark. *Co-opted Members*: H. Burke (Past Chairman of Council); H. G. Gregory (Immediate Past Chairman of Council).

The *Ad Hoc* Committee dealt expeditiously with their task and their report was placed before Council on 23rd July, 1959. After discussing it at the Council meeting, the Report was referred to all Region, Section and Standing Committees for study and comment. This important work is still continuing.

finance

The financial affairs of the Institution have, as always, been kept under the closest possible scrutiny by the Finance and General Purposes Committee. During the past year I have had the honour of being Chairman of this Committee and I can assure you that it is most thorough and assiduous in its application to its duties. You will recall that in my Report last year, I informed you that your Council had come to the conclusion that it was essential for the future well-being of the Institution that we budgeted for an annual surplus of 10% of our income. This surplus is necessary not just to increase our expenditure, but rather to enable us to make more adequate provision for the future. Our Institution's main period of expansion has taken place in the past 15 years. During the whole of that time, we have suffered with everyone else in the battle against inflation, with a result that our provisions for the future have not really been on a generous enough scale.

When surveying detailed budget proposals at the beginning of the year, it was obvious to the Finance and General Purposes Committee that a surplus of 10% of income was quite impossible and that it would be necessary to appeal to the membership to accept an increase in subscriptions. As I have just mentioned, the proposed rates of increased subscriptions were accepted by the members at the Extraordinary General Meeting. This increased income is not, of course, shown in the accounts for the year under review, since the new rates were not designed to come into effect until 1st July, 1959, and will, therefore be the subject of next year's Report, but I can say now that your Council has been tremendously encouraged by the loyal way in which the increased subscriptions have been accepted.

May I now direct your attention to the details of our Accounts which are published on pages 72 - 74 of the January, 1960 Journal. The figures are extremely encouraging. You will observe that our total expenditure amounted to £87,268 as compared with a total of £87,233 last year, that is, an increase of only £35 — a truly negligible sum. I think it is true to say that this is the first time since the end of the War that we have managed to contain inflation. An examination of the details of individual heads of expenditure, compared with their corresponding figures for last year, will reveal to you how rigidly your Finance and General Purposes Committee have controlled their budgeting. In this, they have been helped, not only by Headquarters staff, who have been meticulous in their attention to matters of economy, but also by all our voluntary officers throughout the Institution, whose work on our behalf in an unpaid capacity has contributed so much to the success of our efforts.

Having kept our expenditure so closely under control, it is very gratifying to be able to report a modest increase in our income. Annual subscriptions were increased by £661 and income under various heads of admission fees was £1,350 more than last year. These two items together amount to rather more than £2,000. Our income from the Journal was also slightly higher than last year, which, coupled with the fact that the expenditure was lower, has enabled the Journal to make an increased contribution to our expenses. We are deeply indebted to the Editorial Committee for their skilled management of the Journal and I propose to say more of this shortly. The net result of our financial administration during the year is that the excess of income over expenditure of £5,789 is £2,242 more than in the previous year. I am sure you will agree with me that this is highly satisfactory.

We were fortunate, too, in that during the year we recovered from the Inland Revenue the sum of £4,470, being refund of income tax paid on members' covenanted subscriptions. You will find this item shown in the Appropriation Account. You will recall that it was reported two years ago that the Revenue had challenged our right to this refund and withheld payment. However, we pressed our appeal and this payment represents a refund of two years. You will all by now be aware that under the Finance Act of 1958, members of professional institutions approved by the Revenue may now claim relief of tax from their personal income tax for their annual subscriptions. Your Council has, therefore, decided to discontinue the scheme for covenanted subscriptions and no further members will be invited to sign covenants. The covenants in force must of course run their due term of seven years from entering the covenant. Fortunately, by far the greatest number of covenants expire this year. Only a very small number continue to run for the next year or so and on expiry, those members, too, will be able to claim the benefit of this provision in the Finance Act. The covenanting scheme was of very real value to the Institution at a time of need, and I should like now formally to place on record your Council's appreciation to all those members who signed covenants and thus enabled us to reclaim the tax from the Revenue

In addition to our usual provisions for depreciation, maintenance and the like, you will notice in the Appropriation Account that we have one or two special provisions. We have set aside the sum of £560 towards the costs of our Royal Charter Petition expenses. We have transferred also £1,500 to our Building Maintenance Reserve and we have set aside the sum of £1,000 towards the cost of our Secretary's visit to our Commonwealth Councils and Sections in this coming year.

It is now nearly five years since we took possession of our Headquaters at 10 Chesterfield Street and it became necessary at the beginning of the year to consider a complete redecoration of the premises. A special allocation from the Appropriation Account has enabled us to complete this work in one year instead of spreading it over two years, as we had originally planned. The extensive use of our Headquarters makes it necessary to have major redecorations every four or five years, and on the present costs it is obvious that we shall have to make a provision of £1,000 a year to meet these charges. It will, therefore, be your Council's policy in future to make an annual provision of £1,000 to enable our Headquarters to be kept in first-class condition.

The adoption of the accounts is a separate item on the Agenda and you will have an opportunity then of asking any questions you care to put.

Region and Section activities

Turning now to some other aspects of our work during the year, I should like first to refer to our Region and Section activities which have continued to flourish. There are now within the United Kingdom of Regional organisation 38 Senior Sections, 12 Graduate Sections and a special Student Section at Loughborough College. Outside the U.K. we have our Australian Council with Sections in Melbourne, Sydney and Adelaide, and the South African Council with its headquarters in Johannesburg. We also have Sections in New Zealand, and in India, in Bombay and Calcutta. Our Section in Canada, too, although struggling against immense difficulties, is slowly making progress, and has its headquarters in Toronto. Additional to these organised Sections outside the United Kingdom, we have also corresponding members in the Middle East, in West Africa and in Rangoon, who enable us to keep in touch with our thinly scattered membership in those areas.

conferences

In my Report last year I told you of your Council's decision to abandon the practice of arranging annual residential conferences as a matter of routine and habit, but instead to encourage the holding of more Regional and specialised conferences. I am, therefore, pleased to be able to report that several Sections promoted important and highly interesting conferences during the past year. They have all been reported in our Journal and it would be impossible for me here to give detailed accounts of all of them. Regional Conferences of one or two days' duration, where members with a common interest can exchange views and discuss particular problems, can be extremely valuable, and these Conferences place such activities within the reach of a very much greater number of members than the larger scale national residential conferences, since they involve much less loss of time in travelling, and of course, they are much less expensive. I hope that these short local conferences will become more frequent as experience in their organisation is gained.

It is in the Regions and Sections that the great bulk of the Institution's professional work is done; I do not know of any other professional Institution which has such an extensive net-work of local Sections as we do; very few of our members indeed are out of reach of a centre of Institution activity. The success of these local activities depends entirely upon the local Officers and Committees, all of whom are volunteers, and I should like to express to them all the most sincere appreciation of your Council for their untiring efforts. I should like particularly to mention the Honorary Secretaries. They carry a heavy burden of duties on our behalf, and I am afraid we sometimes tend to take their services for granted and show an apparent lack of appreciation. I do assure all our Honorary Secretaries, however, that they are vital members of our Organisation. Without them we should be poor indeed! A professional Institution's strength lies entirely in the extent to which members are prepared to contribute to its activities, and to give of their own free time, and often money, to the promotion of its objects. We are exceptionally well served in this way in our Institution.

The annual Conference of Region and Section Honorary Secretaries and Treasurers was held at Head Office in May last. There was a good attendance and valuable discussions took place on the Institution. The Conference is a very great help in maintaining the good relations which exist between Honorary Secretaries and our permanent staff at Headquarters.

In addition to the work of our local Officers and Committees, a very large number of members of the Institution give service in other ways. They prepare Papers, they comment on draft Standard specifications, they serve on Boards of Governors of technical colleges and on Engineering Advisory Councils, and in numerous other ways they help not only the Institution, but their profession and the community at large. There is tremendous satisfaction to be gained in public service of this kind and not the least of the rewards is the warm friendships which are made. During my term of office, I have had the privilege of visiting many of our Regions and Sections. I have been deeply grateful for the warm reception which I have always been given, and I have been tremendously impressed and encouraged by the high level of enthusiasm which is sustained.

visitors

We have been fortunate in welcoming to Headquarters a number of members who have been visiting the United Kingdom from other parts of the world. Members from the United Kingdom, too, who have been visiting other parts of the world have reported on the very warm welcome which they have been given. These personal contacts are invaluable in maintaining the strong sense of personal membership which is so important to the Institution and its members.

Standing Committees

As in the past, our Standing Committees who are responsible for so much of the day-to-day routine of

the Institution have been very busy during the year, and I should like to give you a brief account of some of their activities.

Education Committee

The Education Committee has been mainly occupied with the consideration of claims for exemption against our new examination which comes into force in this coming year. A total of 87 courses have been examined in detail, submitted from 17 Colleges of Technology and 26 Universities. Since a large number of the entrants to the Institution obtain exemption from part or parts of our examination by such qualifications as Higher National Certificate, Higher National Diplomas, the Diploma in Technology, or University Degrees, this work of our Education Committee is of great importance since it determines, from the academic point of view, the standard of future membership. Various engineering courses in Commonwealth Universities have been examined; the number of Universities involved were six from Canada, five from Australia, three from South Africa, and two from New Zealand. Close co-operation is maintained between the Education Committee and our Councils and Sections in these Commonwealth countries, and the detailed information and comments which are supplied by our officers are of immense value to the Education Committee.

I should like in particular to comment upon a Report which was received from our members in Toronto. They prepared a most detailed survey on educational progress, *vis à vis* production engineering in Canada, and I should like to congratulate them on this very comprehensive Report. I was personally especially interested in this Report, since I myself spent many years of my young life in Canada and I believe that there is a great future for our Institution in that wonderful country.

A new brochure entitled "A Career in Production Engineering" was published during the year, and this has been very well received by schools and technical colleges and training officers in industry. The demand was so great that the first printing was soon exhausted and a second edition has been published for distribution to youth employment officers and Heads of Secondary Grammar Modern schools. A small exhibition panel has been made which illustrates production engineering as a career, and has been shown at several careers exhibitions.

The Education and Membership Committees have together been concerned with the study of our practical training requirements, and a special Sub-Committee, under the Chairmanship of Mr. A. A. Jacobsen, has submitted an interim report to the two Committees. Work on this very important study is proceeding and the Committees welcome the trend towards closer relations between college and industry to ensure that adequate and correlated practical training is available to students, particularly those who are members of Sandwich Courses. Courses leading to a first degree in Production Engineering are offered in the Universities of Durham, Manchester, and Trinity College, Dublin. Research work in Production Engineering is now being undertaken in the Universities of London, Manchester, Birmingham, Sheffield, Leeds and Glasgow. The development of Colleges of Advanced Technology and the award of the Diploma in Technology is very important to the Institution. Release from industry for Sandwich Courses in these Colleges is growing satisfactorily, but I hope that many more firms will come to realise the value of these courses and will make it possible for more and more of their young production engineers to take advantage of these advanced studies. The Birmingham College of Technology had this year the first successes in the country for the award of the Diploma in Technology in Production Engineering, when eight Diplomas were awarded. Courses for Higher National Diplomas in Production Engineering or Mechanical/Production are now offered at the following technical colleges :- Luton, Bolton, Gateshead, Enfield, Glasgow, Twickenham, Smethwick, Cardiff, Leicester, Dagenham and The Borough Polytechnic. There are now 59 Technical Colleges offering courses for the Higher National Certificate in Production Engineering and 571 Certificates were awarded in 1958. It is pleasing to be able to report that the Technical College in Belfast has now made provision for a course leading to the Higher National Certificate in Production Engineering, and a joint Committee for the award of these certificates in Northern Ireland has been formed.

examinations

There were 492 candidates registered for the 1958 examinations as against 242 in the previous year. This growth of interest in our examinations is very encouraging, and I hope it will be maintained when our new examination comes into force next year. There may well be a fall in numbers for a year or two, since many candidates may now have to take rather longer in their preparation for the examination. This, however, is all to the good, since in a world when technology and science are expanding so rapidly it is essential that our own examination keeps pace.

Education Discussion Groups

The Education Discussion Group in Birmingham has had an active year. Visits to Technical Colleges and industrial works have been arranged, and some very useful discussions on educational problems have been held. Mr. F. W. Cooper, the Institution's Education Officer, has made numerous visits to firms and Colleges and Universities throughout the year. He is a most valuable member of our Headquarters staff and his services are in constant demand.

The London Group now consists of 30 active members. Visits were paid to Messrs. C.V.A. Jigs, Moulds and Tools Ltd., Hove; Thomas Mercer (Air Gauges) Ltd., Staines; E.M.I. Electronics, Hayes; and Hoover Ltd., Perivale, Middlesex.

Mr. W. Hird, of Twickenham Technical College, led discussions on "Automatic Lathes" and talks were given by Mr. L. C. Read, of W. E. Sykes Ltd., Staines, on "Gear Measurement and Production";

by Mr. J. W. K. Murch, of Enfield Technical College, on the "Teaching of Work Study"; and by Mr. W. W. C. Gee, of Twickenham Technical College, on "Electronics in Production Engineering".

Schofield Travel Scholarships

Although the entry for the Scholarship this year was small, competition was very keen and a Scholarship was awarded to Mr. S. D. Hollander. Mr. Hollander is now in America. I should like to express the Institution's appreciation to Mr. Hollander's employers, Combined Technical Services Ltd., who added substantially to the value of the Scholarship, and this has enabled Mr. Hollander to extend his stay in America. Your Council have decided to increase the value of the Scholarship from £250 a year to a total of £1,500 to be spent in the next three years. This may take the form of three Scholarships worth £500 each or two Scholarships worth £750 each. The actual decision will depend upon the quality and number of the entrants.

The Lord Austin Prize

The standard of the essays submitted this year was disappointing and the Awards Sub-Committee decided that no award should be made. The Chairman of the Education Committee during the year was Mr. J. France, and of the Awards Sub-Committee Mr. W. E. Park.

Membership Committee

In my Report last year I mentioned that our total membership had been almost stationary for the past two or three years, the number of entrants roughly equalling those we lost through death or lapsing of membership. It is very pleasing to record, therefore, that there has been a substantial increase in the number of candidates for election during the past year, and the Membership Committee has been very busy indeed dealing with this increased number of applications. Altogether a total of 2,301 applications for membership were considered. Of these 1,489 were elected to membership; 361 were referred back for further examination requirements. The total membership of the Institution at the 30th June, 1959, was 10,998.

Grades	Membership Total at 30.6.58	Membership Total at 30.6.59
Honorary Members	7	7
Members	1,724	1,693
Associate Members	5,214	5,381
Associates	144	142
Graduates	2,144	2,497
Students	888	1,023
Affiliated Organisations	259	255
	10,380	10,998

The Membership Committee pays particular attention to its method of dealing with applications and some changes in procedure have been made which not only speed up the process, of consideration, but have also offered us some savings in expenses. The principal change concerns the applications from junior members. These are now considered in detail by the Education Officer and the Registrar who present their recommendations to the Membership Committee. The Membership Committee also gave detailed consideration to the Articles of Association governing election to membership, and made a number of recommendations to the Council which were approved and have been made known to the membership at large. Miss K. Allan, the Institution's Registrar, has attended a number of Section Committee meetings during the year for detailed discussions on membership procedure; this has enabled a closer understanding to be established between local Sections and the Membership Committee. The Chairman of the Membership Committee during the year was Mr. K. J. Hume.

Hazleton Memorial Library

Because of limitations of space and expense, our Library is naturally a modest one, but it is nevertheless extremely busy. During the year extensive Bibliographies on Quality Control and Materials Handling were prepared by the Librarian and her Assistant, and published by the Institution. Work on a major Bibliography on Technological Education was completed during the year and published in July. This very important work has received most favourable comment from a number of sources. The Library staff have received innumerable enquiries during the year, and have continued to distribute lists of abstracts on various subjects. The number of books and periodicals borrowed by members during the year amounted to 4,836 — a very large number in relation to the size of the Library and of our membership.

The very wide range of subjects included in Production Engineering makes it extremely difficult to anticipate and provide for within such a small Library all the enquiries likely to be received, and we frequently have to call upon the services of other Libraries which, I am glad to say, are readily forthcoming. Correspondingly, of course, our Library is frequently called upon for help by other Libraries. Our Library activities constitute one of the most valuable services we can offer our members and I very much hope that as the Institution expands and gains in strength, both numerically and financially, our Library will become much enlarged. Mr. L. W. Bailey was Chairman of the Committee during the year, and Miss M. L. South continues as Librarian.

Research and Technical Committee

There have been considerable changes in the work of the Research and Technical Committee during the year. Several *Ad Hoc* Sub-Committees completed their discussions and submitted their reports and new Sub-Committees were established. The Committee also gave some thought to its Terms of Reference and you will notice that the name of the Committee has been changed from the Research Committee

to the Research and Technical Committee. It is felt that this name more closely relates the Committee to the work it does on our behalf.

A Sub-Committee under the Chairmanship of Mr. R. N. Marland completed and presented a Report on "Improved Material Utilisation," which was published in December, 1959.

A Report entitled "Quality — Its Creation and Control" was completed by a Sub-Committee under the Chairmanship of Mr. R. K. Grunau. When this Report was published it attracted widespread interest and a large number of copies were sold. It was decided to follow the publication of this Report with a Conference on the subject of "Quality". Accordingly, a Sub-Committee, to make the necessary arrangements, was established under the Chairmanship of Mr. B. H. Dyson, with representatives from The Institution of Engineering Inspection and The British Productivity Council.

The Conference, under the title "Quality in Industry", was held in Buxton in June and attracted an attendance of 175 delegates. The Conference received a good measure of publicity and several of the Papers were subsequently published in the Technical Press, in addition to our own Journal. A Sub-Committee was formed during the year under the Chairmanship of Mr. L. W. Bailey to consider "Computers and Production Control". This work is proceeding and it is hoped that a report will become available some time in 1960. Another Sub-Committee under the Chairmanship of Mr. A. P. Oppenheimer is studying "Co-ordination of Production Management Techniques". The Report of this Sub-Committee is also expected during 1960.

Since we abandoned the practice of promoting Annual National Conferences as a matter of habit, the Research and Technical Committee has been charged by the Council with the responsibility of watching technical trends and advising the Council on the subjects and timing of future National Conferences.

Mr. B. G. L. Jackman was Chairman of the Committee during the year and the administrative work was the responsibility of Mr. I. King, our Assistant Technical Officer at Headquarters.

Materials Handling Group

Mr. A. G. Hayek, who had been Chairman of the Group since October, 1958, retired during the year due to pressure of business commitments and Mr. F. E. Rattlidge was elected Chairman in his place. Mr. Hayek's unbounded energy and enthusiasm were undoubtedly responsible for the rapid progress which the Group has made.

A Materials Handling Convention, the third of its kind to be organised by the Group, was held in Brighton in September, 1958. This Convention was planned on somewhat different lines from previous occasions, and consisted mainly of actual studies of handling problems carried out in local factories. Many members at the Convention were able to study practical handling problems under working conditions, and I should like to express our appreciation to the managements of the firms concerned who made this very practical approach possible. Undoubtedly this was a very successful convention from which valuable lessons were learned for future conventions.

The Materials Handling Group maintains active liaison with other Institutions and organisations having an interest in Materials Handling. Lengthy discussions took place with the Institute of Materials Handling on the teaching of this subject in technical colleges and the preparation of suitable syllabuses. The Group represented the Institution on the National Joint Committee on Materials Handling. A Joint Study Group has been set up with the Building Research Station to study co-ordination between production engineers and architects.

Standards Committee

As in previous years the principal work of the Standards Committee has been to comment on draft British Standard Specifications and to nominate Institution representatives to serve on the B.S.I. Technical Committees. The Institution has representatives on some 140 of these Committees.

A Sub-Committee on International Standardisation, under the Chairmanship of Mr. T. A. C. Sparling, has been established to consider draft international recommendations of interest to production engineers; to make suggestions regarding international standards; and to investigate problems of international standards referred to the Institution from the British Standards Institution. The Joint Advisory Committee of the Institution and the B.S.I. on the use of standards in industry has held regular meetings. The Joint Committee organised a Conference for Standards Engineers (the fifth of its kind) which was held in London in June, 1958, and was opened by Lord Halsbury, the President of the Institution.

Mr. H. A. R. Binney, Director of the B.S.I., was Chairman of the Conference, which was attended by 250 delegates. One of the proposals considered at the Conference and which is still under review, was the establishment of a Standards Society.

A Sub-Committee of the Joint Committee was established to produce a booklet on "The Setting Up of a Company Standards Department". This work has now been published. The Chairman of the Standards Committee during the year was Mr. R. E. Mills.

Editorial Committee

As I mentioned earlier in this report, we are very much indebted to the Editorial Committee and to Miss Bremner, the Editor of the Journal, for maintaining such a high standard in our Journal and for their very skilful management of its financial affairs. When the Journal was published in its new form in January, 1953, it was warmly welcomed by members as a tremendous advance on our former publication. Nevertheless, there is always room for improvement and during the year our Editorial Committee has been very closely studying proposals for further

development of the Journal, which not only is sent to our members but has a growing circulation outside the membership.

The policy of the Editorial Committee may be summed up as follows :-

(a) to report the proceedings of the Institution;
(b) to provide news of the Institution activities, past, present and future, and to provide news of members;
(c) to provide news and comment on activities likely to be of value and interest to production engineers;
(d) to maintain the Journal as the principal means of communication and contact between the members, one with another, and between the membership and Institution Headquarters;
(e) to attempt, as far as practicable, to ensure that the Journal does not become a financial burden to the Institution.

Change for the sake of change can sometimes be a good thing in itself, if only as a means of drawing attention to other changes. It will not have escaped your notice that the Journal in which this report is published has introduced several changes in presentation. There is a new cover and there are various changes in the presentation of the editorial material. You will notice also a change of title, our Journal now carrying the name of "The Production Engineer". Several changes of greater importance than style and presentation are also being introduced into the Journal. The editorial content will be enlarged: it is hoped to include a greater coverage of Region and Section activities; articles on the work of the Institution Standing Committees; communications from members; progress reports from universities and technical colleges engaged on production engineering research and regular news and comment on production engineering activities in fields outside the Institution. In considering the advisability of making these proposed changes, the Editorial Committee has sought advice and guidance from the Chairmen of other Standing Committees, from Region and Section Committees, from the Advertising Agents and from the Journal Printers; and the Chairman of the Committee has asked me to express his appreciation of all the help that was received.

In addition to this close study of editorial presentation and content of the Journal, considerable attention has been paid to the management of its business affairs. A number of meetings between the Chairman of the Committee, the Advertising Agents and the Journal Printers have taken place. I am very glad to say that our Editorial Committee enjoys the happiest of relationships with the Advertising Agents and the Journal Printers.

It will not have escaped the notice of members that our Journal continued to appear regularly at the appointed time throughout the dispute in the printing trade, when so many other publications were brought to a standstill. We are all most grateful to our Journal Printers and to their staff for this excellent service. During the year the Journal contained 778 pages of editorial material and 1,162 pages of advertisements. This balance between editorial and advertising matter has been found necessary to maintain the financial stability of the Journal and it is proposed that this ratio should be continued in future.

Institution personalities and affairs have been well reported in the National and Technical Press and by the B.B.C. during the year, and there is every evidence that the public's knowledge of and appreciation of the work of the Institution are rapidly expanding.

The Chairman of the Committee was Mr. B. E. Stokes.

Papers Committee

The principal task of the Papers Committee is to promote and maintain the supply of first quality Papers for the Journal, to make arrangements for the presentation of the Institution's Named Papers, and to adjudicate on the Annual Medal Awards. Close collaboration is maintained between the Papers Committee and the Editorial Committee in order to ensure an adequate supply of good publishable material for the Journal.

During the year the Papers Committee assessed 97 Papers and Theses, of which 51 were recommended for publication. The Committee is greatly helped in its work by the Corresponding Members elected by Sections throughout the country, and is most appreciative of the contribution made by these Corresponding Members.

In addition to assessing material submitted, the Committee commissioned for publication comprehensive reviews on two subjects of great interest to production engineers :

(a) developments in copy turning; and
(b) current practice in fine boring.

Named Papers

During the year the following Named Papers were presented :-

The 1958 *Sir Alfred Herbert Paper* was presented at the Royal Institution, London, on 11th December, 1958, by Sir Cecil Weir, a Past President, who took as his subject "The European Common Market, The Free Trade Area, and The Production Engineer". The President of the Institution, Lord Halsbury, was in the Chair, and a report of the meeting appeared in the February, 1959, Journal.

The 1958 *Viscount Nuffield Paper* was presented at the University of Birmingham on 11th March, 1958, by Dr. N. P. Inglis, Research Director, Metals Division, I.C.I. Ltd., who spoke on "The Production, Fabrication, Properties and Uses of Some of the Newer Metals". Mr. G. Ronald Pryor, Vice-President of the Institution, occupied the Chair, and a report of the meeting appeared in the May, 1959, Journal.

The 1959 *Lord Sempill Paper* was presented on 16th April, 1959, at the Seventh Aircraft Production Conference at Southampton, by Marshal of the Royal

Air Force, Lord Douglas of Kirtleside, who spoke on "The Operator's Point of View". The President, Lord Halsbury, was in the Chair, and the Paper appeared in the June, 1959, Journal.

The 1958 *George Bray Memorial Lecture* was presented at The Royal Commonwealth Society, London, on 29th April, 1959, by Mr. Mark Bogod, Director of J. Lyons & Co. Ltd., and was entitled "The Search for Productivity in a Food Industry". Mr. G. Ronald Pryor was in the Chair, and the meeting was reported in the July, 1959, Journal.

Medal Awards, 1957 - 1958

The Papers Committee, having carefully considered the Papers eligible for the Awards, made the following recommendations:

The Medal for the best Paper presented by a Member and also *The Hutchinson Memorial Award* (for the best Paper presented by a Graduate) to Mr. A. J. Lawrance (since transferred to A.M.I.Prod.E.), of Kimber-Allen Ltd., for his Paper on "The Application of Spark Erosion Machining".

The Medal for the best Paper presented by a non-member to Dr. J. E. Littlechild, of the United Kingdom Atomic Energy Authority, for his Paper "Production Problems Associated with Industrial Atomic Energy".

The J. D. Scaife Medal Award for the best Paper published in the Journal other than those presented to Sections or Regions jointly to Professor N. A. Dudley, M.I.Prod.E., of the University of Birmingham, for his Paper "Output Pattern of Repetitive Tasks, with special reference to Compensating Relaxation Allowances"; and Mr. W. J. Kease (non-member), of A.E.I.-Hotpoint Ltd., for his Paper "Computer-assisted Production Control".

This was the first presentation of the J. D. Scaife Award.

Honours

Her Majesty the Queen has been graciously pleased to confer honours on members of the Institution whose names are given below:

O.B.E. — R. W. Mann; G. Murray.

M.B.E. — W. H. Hodgetts, A. S. Downes.

In addition to the honours mentioned above, His Majesty the King of the Belgians has honoured Mr. B. A. Williams, C.B.E., M.I.Prod.E., by appointing him a Commander of the Order of the Crown.

Obituary

It is with deep regret that the deaths of 42 of our members must be recorded. Their names have been published in the Journal.

Headquarters Staff

Excellent work has been done by our Headquarters staff during the year. As Chairman I come into frequent contact with them all, and I can assure you that they are hard-working and conscientious on your behalf.

While I always think it is wrong to pick out individuals in a hard-working and well-integrated team, I must take the opportunity of paying special tribute to our Secretary, Mr. Woodford, who has had a very busy and difficult year and, in addition to his other duties, has had to grapple with the problems arising from our application for the Charter, which he has done very cheerfully and efficiently. He has been ably assisted in these problems by the Deputy Secretary, Mr. Caselton, who in his quiet and efficient way has coped with all that has been required of him. As Chairman, I take this opportunity of personally thanking them both for their able assistance to me, for without that assistance I would have been unable to carry out my duties to the Institution.

I could also with advantage mention all the other members of the senior staff dealing with education, membership, the editorship of the Journal, and the Library. Space, however, does not permit me to say all I would like to say, so I ask them to accept my statement as an acknowledgment and appreciation of their work.

I am sure you will all join with me at this 36th Annual General Meeting in expressing our thanks for the excellent way in which Mr. Woodford and his staff continue to serve the Institution.

The President

During the course of this report I have expressed my appreciation to many of those good people who have rendered such splendid service to the Institution throughout the year. To the many, both members and non-members, who have contributed to our work but whom I have not been able to mention personally, I express my thanks, but there is one to whom we owe more than any other and that is our President, the Right Honourable the Earl of Halsbury. On 30th June, 1959, Lord Halsbury completed a tenure of two years as our President. He was a regular attender at our Council meetings and at meetings of the Finance and General Purposes Committee. He also gave a vast amount of his time in visiting Regions and Sections and in representing the Institution at meetings and functions of other organisations. Lord Halsbury has added further lustre to the high office of President and has followed magnificently the tradition of service established by his illustrious and distinguished predecessors in office. His engaging personality, the clarity of his mind and the many contributions which he made to our proceedings will be remembered long after we lesser mortals are forgotten.

My period of office as Chairman of Council has been one of the most enjoyable in my whole career. I count myself extremely fortunate to have received the support and encouragement of my friends and colleagues on the Council and highly honoured to have had the distinction and the inspiration of serving under Lord Halsbury's Presidency.

In presenting to you this report of your Council for the year ended 30th June, 1959, I can conscientiously say that your Council have worked hard and well on your behalf.

I move that the report be received.

THE INSTITUTION OF PRODUCTION ENGINEERS

BALANCE SHEET as at 30th JUNE, 1959

1958				£
£				
	Accumulated Funds and Surplus			
25,000	The Viscount Nuffield Gift ...	25,000		
500	The Lord Austin Prize Fund ...	500		
100	The Hutchinson Memorial Fund	100		
500	The George Bray Memorial Fund	500		
26,100				26,100
1,188	Life Subscription Fund ...			1,567
2,000	Building Maintenance Reserve ...	3,500		
	Less Expenditure during year	1,604		
				1,896
30,158	Income and Expenditure Account			37,357
59,446				66,920
64	Melbourne Prize Account ...			69
	Current Liabilities			
6,360	Sundry Creditors	8,025		
243	Subscriptions Received in Advance	351		
6,603				8,376
	Note: Commitments for Expenditure on the Maintenance of the Freehold Premises in excess of the amount reserved amounted to approximately £1,250			
£66,113				£75,365

1958				£
£				
	Fixed Assets			
35,000	Freehold Premises: at cost			35,000
	Freehold Premises: Cost of Alterations and Equipment *less* Donations, Reserves, etc:			
	Balance at 1st July, 1958 ...	3,317		
3,317	*Less* Receipts during year ...	38		3,279
	Furniture, Fittings and Plant at the net amount standing in the Institution's books at 30th June, 1948	1,531		
	Additions *less* Sales	10,817		
		12,348		
5,813	*Less* Depreciation	7,217		5,131
1,100	Fund I'vstmts. at cost: as sch'duled (Market Value £2,510) ...			2,722
45,230				46,132
	Current Assets			
12,786	Sundry Debtors, Deposits and Stocks	11,305		
5,317	Cash at Bank and in Hand ...	14,928		
2,780	United Building Society — Deposit (South Africa)	3,000		
20,883				29,233
£66,113				£75,365

HALSBURY, *President.*

H. W. BOWEN,
Chairman of Council and Finance Committee

W. F. S. WOODFORD, *Secretary.*

Report of the Auditors to the Members of The Institution of Production Engineers

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by the Institution so far as appears from our examination of those books. Audited Balance Sheets and Accounts have been received from each of the Councils and Sections outside the United Kingdom and these have been incorporated in the above Balance Sheet and annexed Income and Expenditure Account. We have examined the above Balance Sheet and annexed Income and Expenditure account which are in agreement with the books of account audited by us and the audited Accounts of the Councils and Sections outside the United Kingdom supplied to us. In our opinion and to the best of our information and according to the explanations given us the said Accounts give the information required by the Companies Act 1948 in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at 30th June, 1959 and the Income and Expenditure Account gives a true and fair view of the excess of income over expenditure for the year ended on that date.

20 Bloomsbury Square,
London, W.C.1.

16*th October*, 1959.

GIBSON, APPLEBY & CO.,
Auditors,
Chartered Accountants.

THE INSTITUTION OF PRODUCTION ENGINEERS

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th JUNE, 1959

1958					1958			
£	£		£	£	£	£		£
		To **Establishment**					By **Subscriptions**	
1,175		Rates	1,194		41,156		Renewals and Arrears ...	41,191
1,658		Light, Heat and Cleaning ...	1,801		624		Transfers	572
588		Repairs and Renewals ...	601		901		New	1,134
	3,421			3,596			Councils and Sections outside	
		„ **Administration**			5,019		U.K.	5,464
2,976		Postage and Telephone ...	2,943			47,700		48,361
4,963		Printing and Stationery ...	4,897				„ **Admission Fees**	
193		Professional Charges and Insurance	408		696		Entrance	784
116		Banking Services—Subscriptions	116		802		Registration	1,344
250		Audit	250		930		Exemption	1,659
		Travel, Entertaining and Meetings (other than Sections) ...	3,368		107		Thesis	98
3,037						2,535		3,885
128		Miscellaneous	47		597		„ **Interest**	511
	11,663			12,029	39,144		„ **Journal**	39,537
23,704		„ **Salaries**		24,570	550		„ **Sale of Proceedings** — Net ...	31
		„ **Sections**			21		„ **Miscellaneous**	11
2,293		United Kingdom	2,338		225		„ **Examinations**	581
3,032		Outside U.K. (Audit Fees £106)	3,393		—		„ **Conferences**	60
1,666		Central Services	1,667		8		„ **Annual Dinner**	80
	6,991			7,398				
		„ **Journal**						
30,465		Printing	29,724					
6,685		Postage and Envelopes ...	6,976					
412		Reporting	144					
	37,562			36,844				
504		„ **Institution Papers**		441				
413		„ **Hazleton Memorial Library** ...		314				
		„ **Schofield Scholarship**						
250		Award	250					
109		Administration	49					
	359			299				
146		„ **Donations and Subscriptions** ...		187				
700		„ **Conferences**		—				
		„ **Miscellaneous**						
62		Press Cuttings	56					
152		Bank Interest and Charges ...	200					
413		New Examinations	—					
—		Promotion and Publicity ...	141					
	627			397				
		„ **Provisions**						
1,143		Depreciation — Furniture and Fittings		1,193				
87,233				87,268				
		„ **Balance**—Excess of Income over						
3,547		Expenditure carried down ...		5,789				
£90,780				£93,057	£90,780			£93,057

APPROPRIATION ACCOUNT

1958			1958		
£	£		£	£	£
—		To **Royal Charter Petition Expenses** ...	560	27,111	By Balance at 1st July, 1958. 30,158
—		„ **Building Maintenance Reserve:-**			„ Excess of Income over Expenditure brought
500		Transfer	1,000	3,547	down 5,789
—		Special Allocation	500		„ **Recovery of Income Tax on Covenanted**
			1,500	—	**Subscriptions** 4,470
—		„ **Secretary's Commonwealth Visit** ...	1,000		
30,158		„ Balance carried forward	37,357		
£30,658			£40,417	£30,658	£40,417

THE INSTITUTION OF PRODUCTION ENGINEERS

INVESTMENTS AT COST, 30th JUNE, 1959

1958 £			£
	United Kingdom		
	The Lord Austin Prize Fund		
	£95 8s. 5d. 3½% War Loan	100	
	£575 8s. 3d. London County 3% Consolidated Stock 1920	400	
500			500
	The Hutchinson Memorial Fund		
100	£95 8s. 5d. 3½% War Loan		100
	The George Bray Memorial Fund		
500	£775 London County 3% Consolidated Stock 1920		500
	Life Subscriptions Fund		
—	£1,248 18s. 9d. 3% Savings Bonds 1955 - 65		1,122
1,100			2,222
	Outside United Kingdom		
	5% Auckland City Council Debentures		
—	Maturing 1st February, 1966	250	
—	Maturing 15th April, 1969	250	
			500
£1,100			£2,722

(Market Value £2,510)

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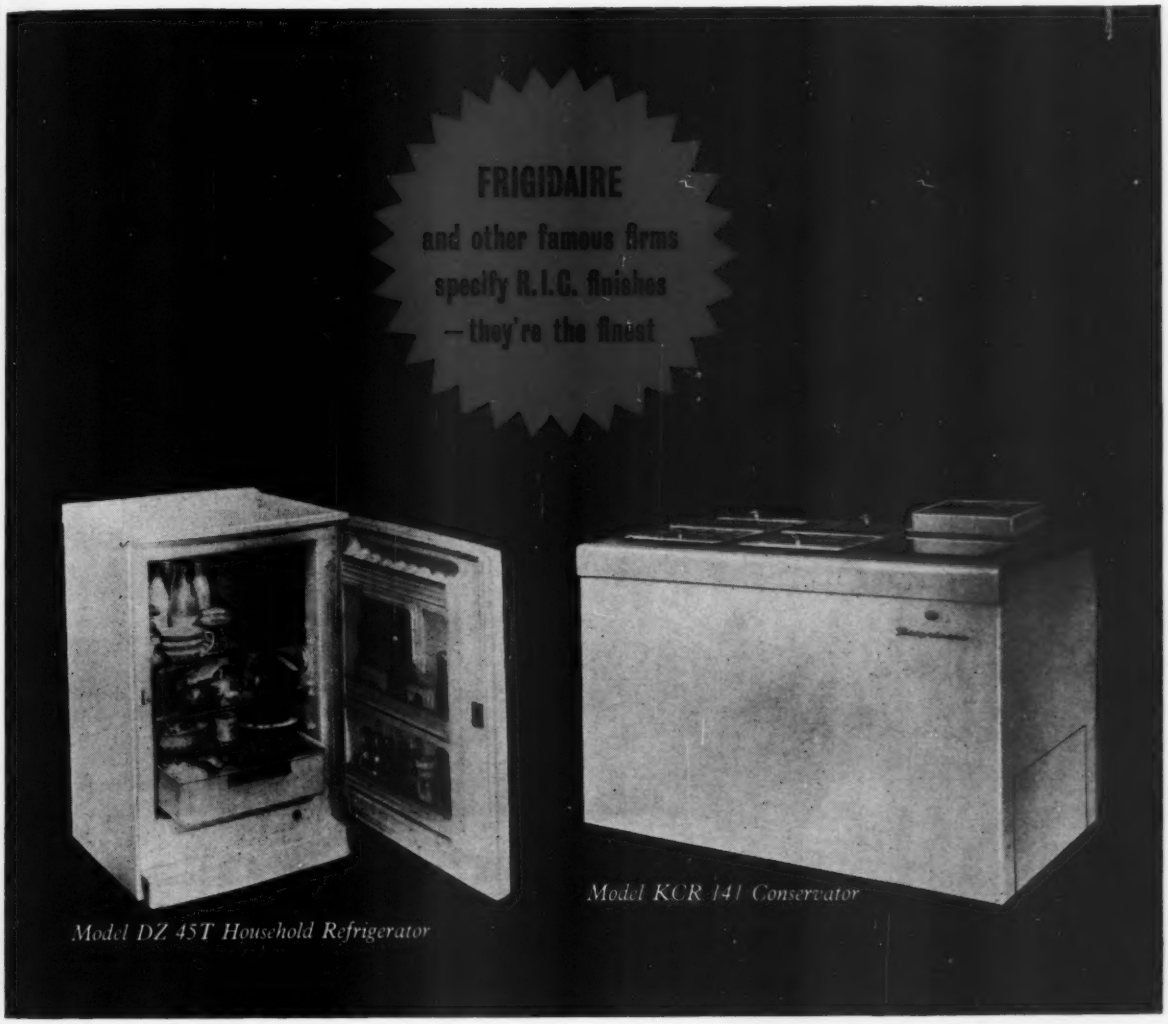

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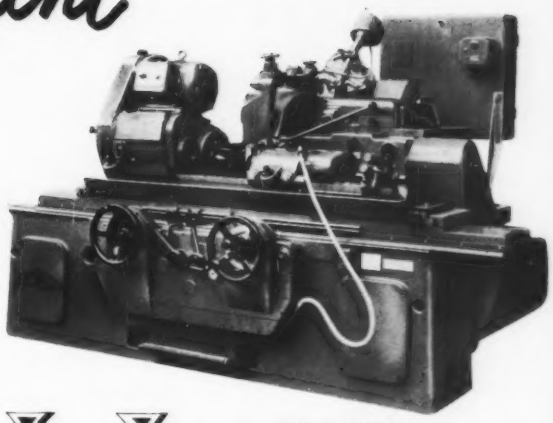

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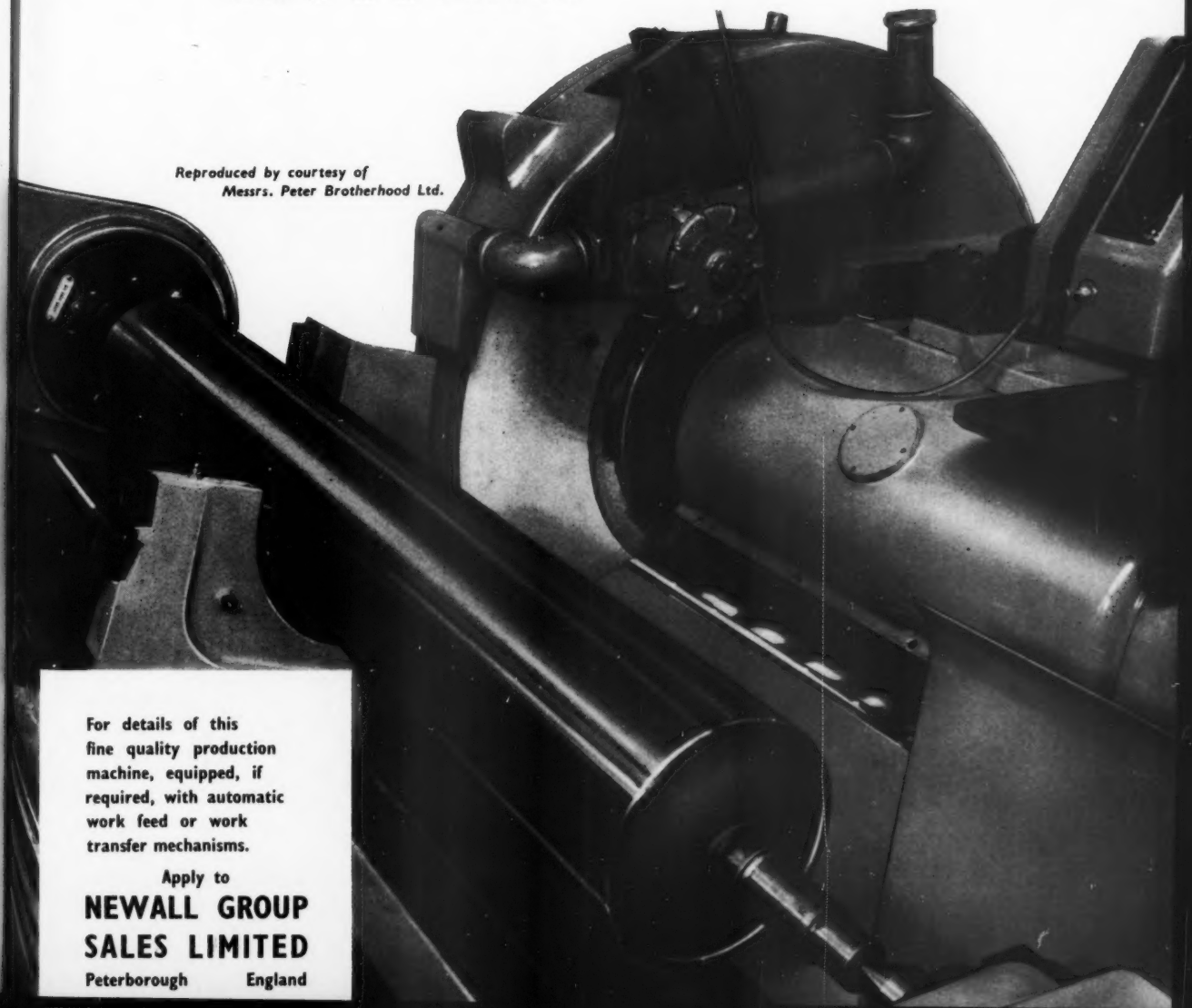

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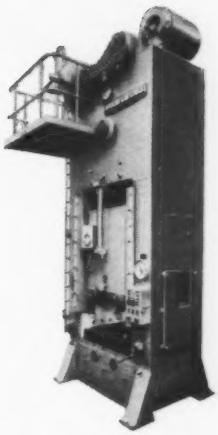

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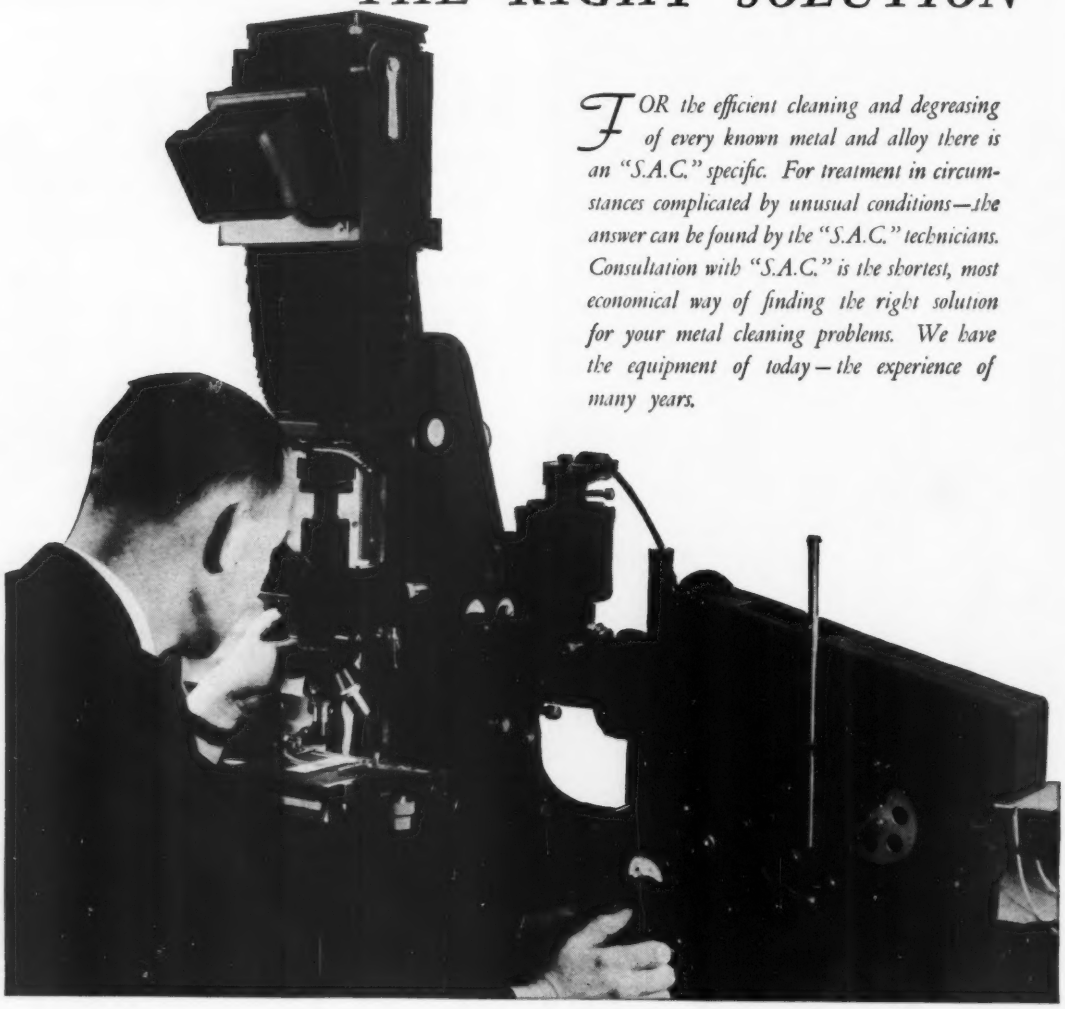

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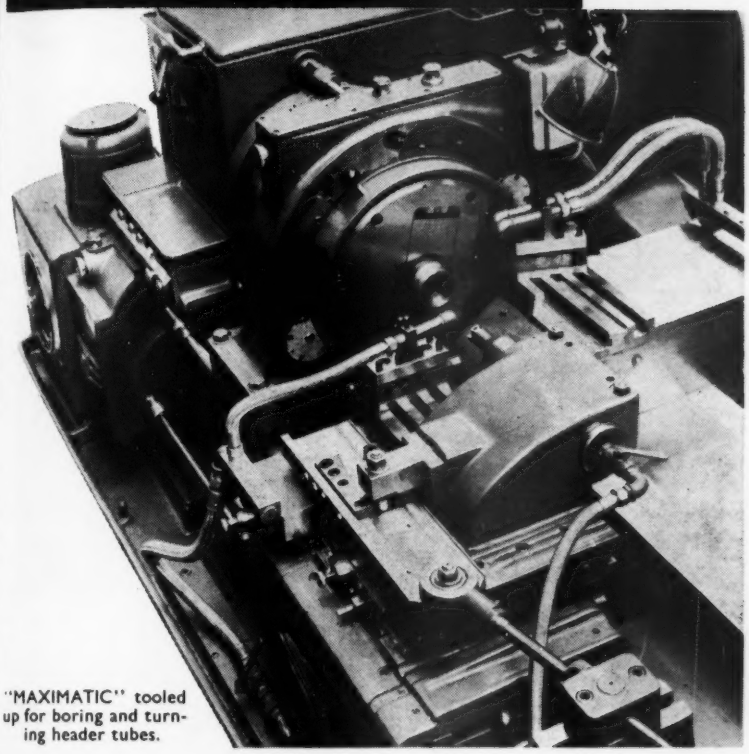
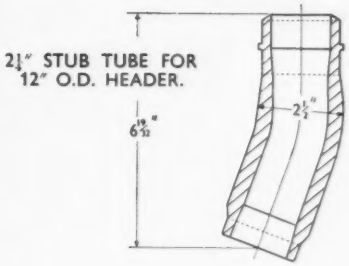
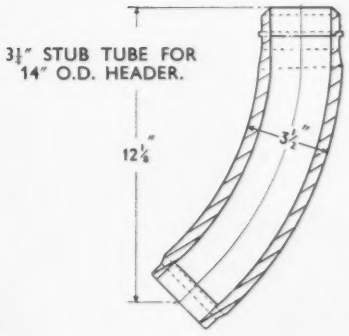
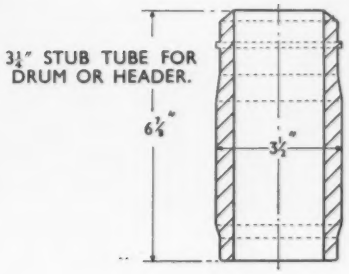


"MAXIMATIC" tooled up for boring and turning header tubes.







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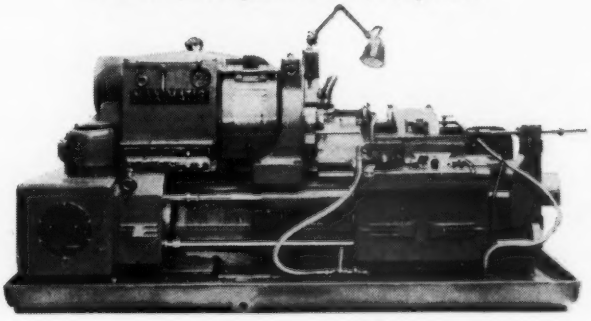

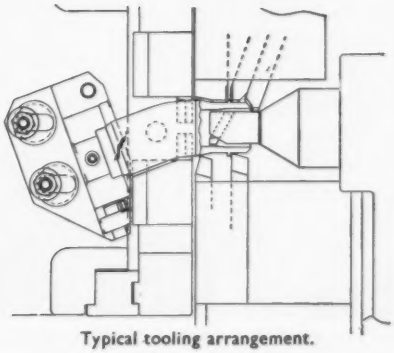

Typical tooling arrangement.

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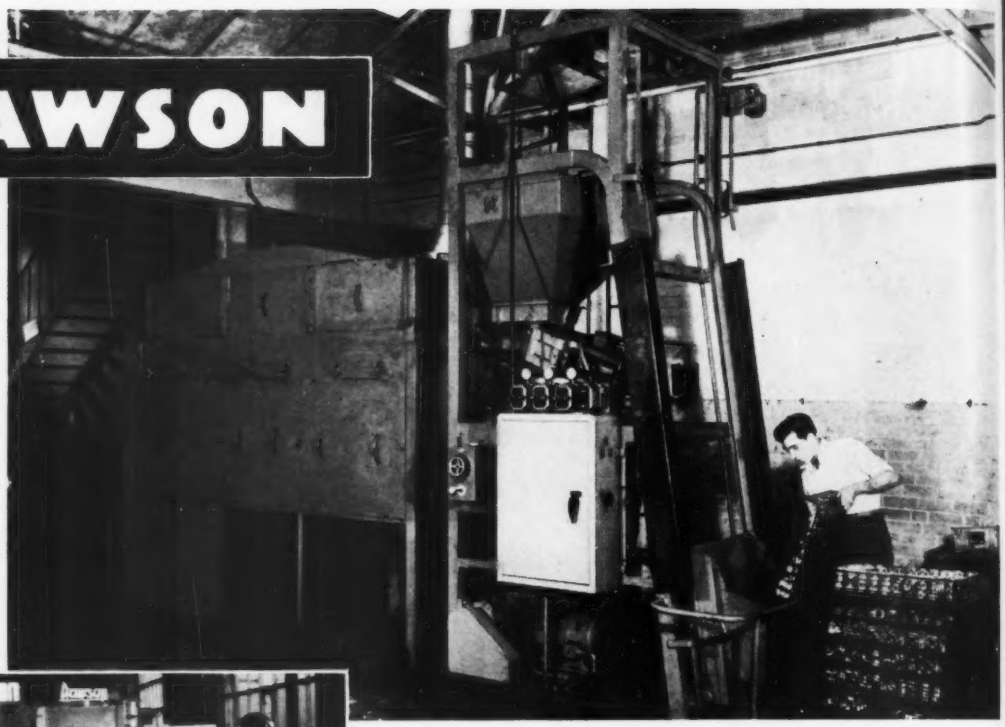
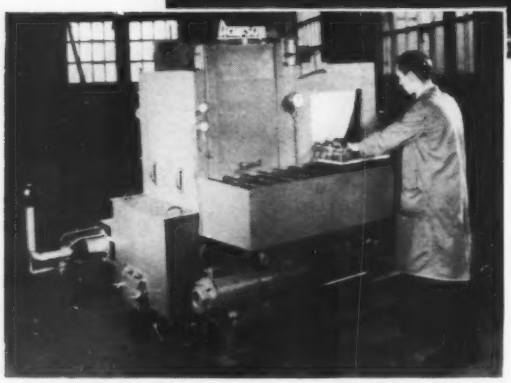
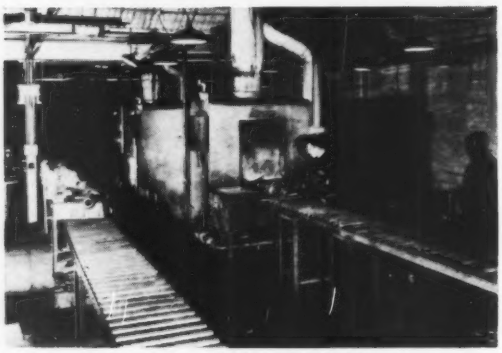


Dawson Rotary Drum Machine with skip hoist for loading. The operator is shown loading the skip with malleable iron pipe fittings.



Dawson Cabinet Type Washing and Drying Machine handling high quality bolts and threaded work.



Dawson Conveyor Type Machine installed for the automatic cleaning of tractor components.

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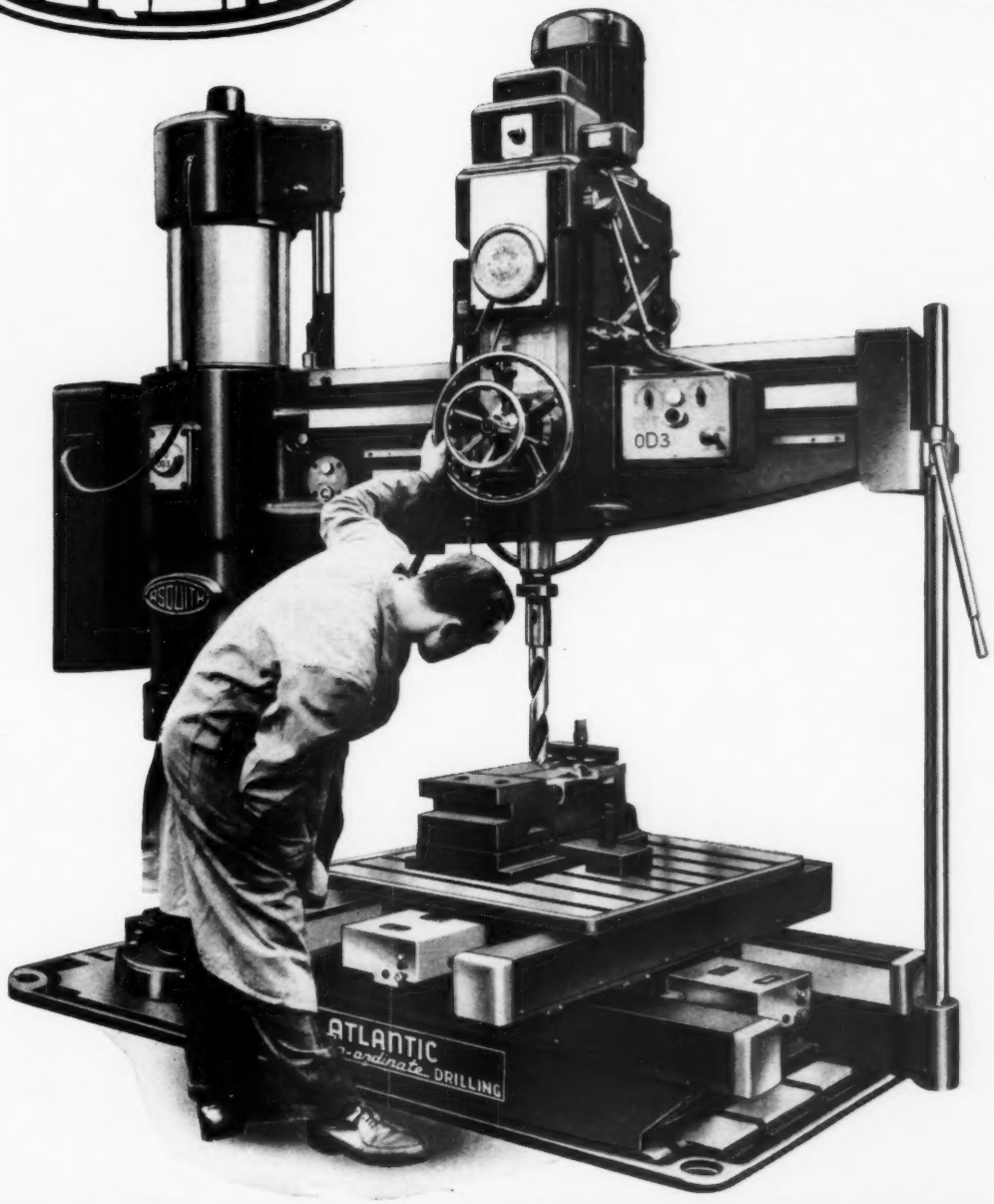
ASQUITH

OD3 RADIAL and
ATLANTIC Co-ordinate Table



for rapid, accurate positioning and holemaking

The Asquith OD3 Radial and the Atlantic Co-ordinate Table provides the ideal combination for rapid drilling or boring of components which require accurate positioning. Setting times are greatly reduced, costly jigs are eliminated and marking off is not necessary. Exact repetition is ensured at any time by tape or punched card Programmed Control and alternatively by Individual Control. Table area is 36 in. × 30in. and drilling rectangle 30 in. × 24 in.

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Sales and Service for the British Isles

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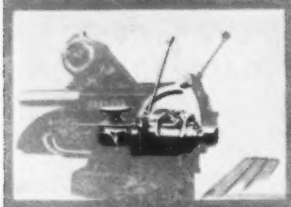
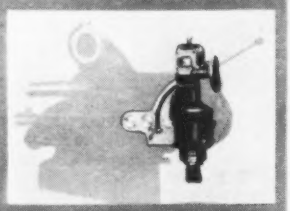
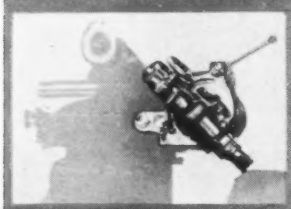
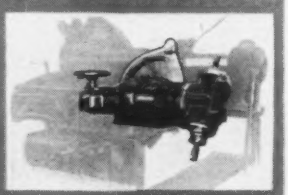
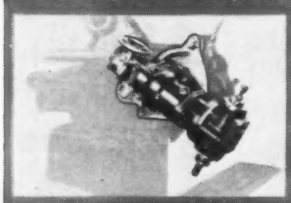
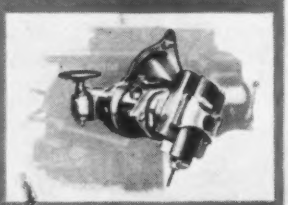




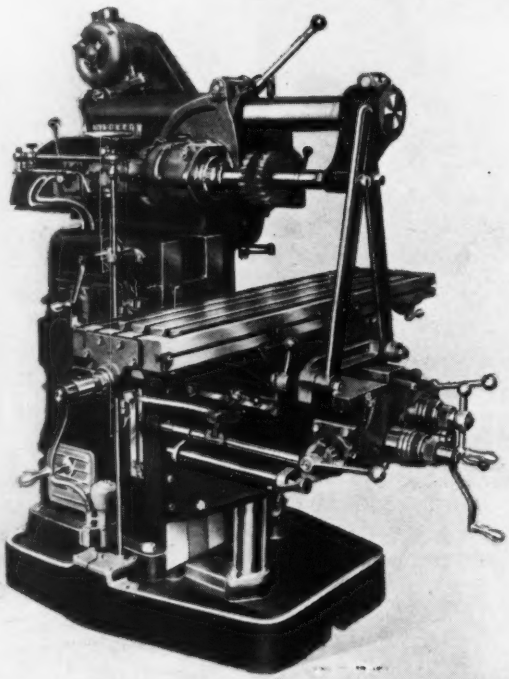








HORIZONTAL
Plus VERTICAL
Plus ANGLE
= ADAPTA MILLING



ADAPTA

The ADAPTA Miller (Model N) illustrated above combines in one machine the advantages of horizontal and vertical mills, while at the same time giving facilities for unusual angle cutting. It is ideal for special tool and die work patterns, moulds, etc., as well as for ordinary batch production.

J. PARKINSON & SON (SHIPLEY) LTD

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P333A

Churchill

MODEL HBM
AUTOMATIC SIZING INTERNAL GRINDING MACHINE

Finishing Jet Engine Bearings

at

FISCHER BEARINGS CO LTD
WOLVERHAMPTON

BRITISH MACHINE TOOL MAKERS ASSOC. LTD

CHURCHILL automatic sizing internal grinding machines are renowned for their accuracy and speed of production, and our illustration shows one of a battery of Model H B M grinders engaged on jet engine bearings at Fischer Bearings Co. Ltd., Wolverhampton.

OUTSTANDING FEATURES INCLUDE:—

- Single or double automatic operation cycle.
- Plunge cut or traverse grinding.
- Feed accelerator reduces production time.
- Diminishing feed rate to zero with variable dwell.
- Adjustable oscillation.

Full details of these and other outstanding advantages sent on request.

Precision plus Production

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Export Sales Organisation: Associated British Machine Tool Makers Ltd., London, Branches and Agents.

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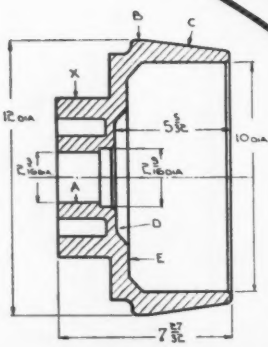
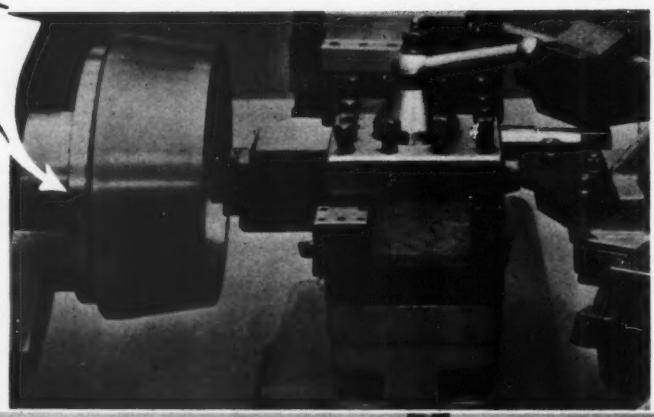
C670-ID

Maximum Production Special Tool Layouts

CLUTCH

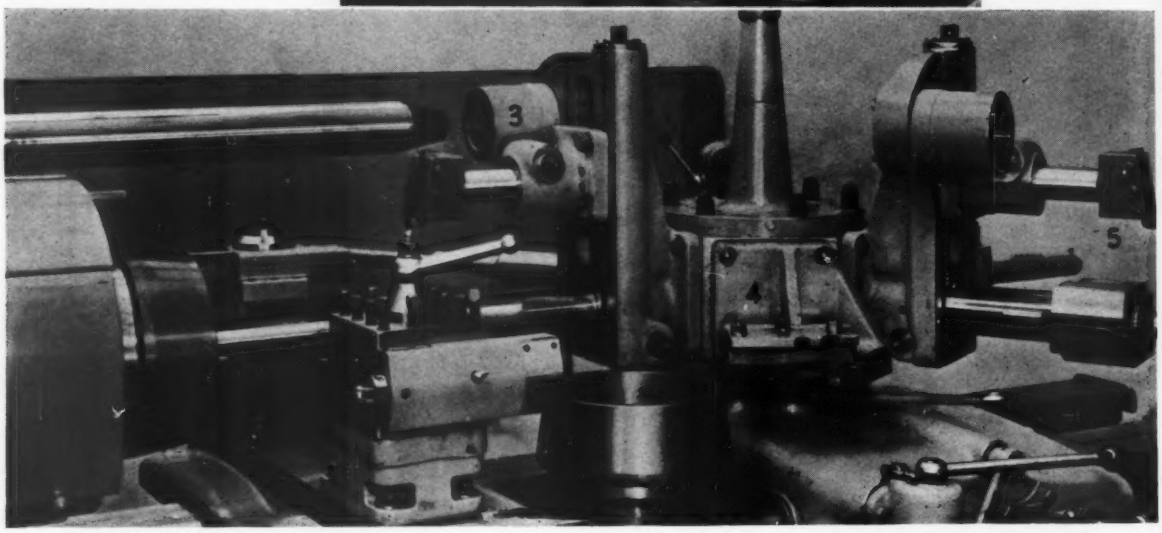




CAST IRON CASTING
Brinell No. 220/228

Floor-to-Floor Time:
17½ mins. each.

Tungsten Carbide Cutting Tools



DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on X (using Loading Attachment)	1	—	—	—	Hand
2. Rough Bore A & 2 5/16" dia. and Chamfer	2	—	375	260	64
3. Face (2 Cuts)	—	Front 1	93	278	64
4. Rough Bore 10" dia. Rough Knee Turn B and Rough Taper Turn C	3	Rear	75	240	44
5. Contour Face D & E (Rough & Finish)	4	Front 3	93/125	242/325	64
6. Finish Bore 10" Finish Knee Turn B and Finish Taper Turn C and Chamfer 10" dia.	5	Rear	125	390	64
7. Chamfer Outside Dias.	—	Front 2	125	390	Hand
8. Finish Microbore 2 5/16" dia.	6	—	580	333	88
9. Remove (using Attachment)	1	—	—	—	Hand

Ward

No. 10 TURRET LATHE

FITTED WITH 18in TUDOR 3-JAW CHUCK

H·W·WARD & CO LTD

SELLY OAK
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TELEPHONE SELLY OAK 1131

ASSOC. BRITISH MACHINE TOOL MAKERS LTD

W656

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SPEEDOMAX "H"

The compact instrument (11" x 12") at low cost

THIS line of indicators, recorders and controllers is unique—there is no comparable instrument available to you today. It is compact, all elements being readily accessible and all major components plug-in, and all moving parts operate by means of a common shaft driven by the positive worm gear of a high speed balancing motor. Limit of error is ± 0·3% and balancing time 1 to 5 seconds.

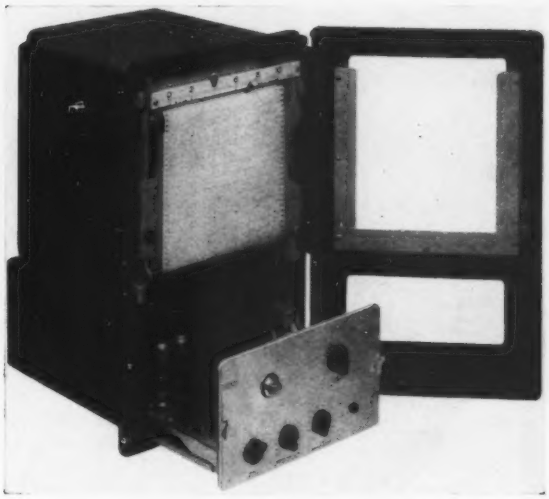
It is lower in cost than any comparable electronic potentiometer available today.

Speedomax "H" with Series 60 Control

Here is a completely new model of the Speedomax Type H potentiometer with additional controls now an integral part of the main instrument.

It is very compact, saving much panel space, being only 17⅝" x 11"x 11"

The Control pulls out like a drawer.



Entirely new, and quite outstanding is this latest L & N introduction—Series 60 Electronic Control. It provides single-action (proportional), 2-action (proportional and reset) and 3-action (proportional, reset and rate) control, and is offered as a separate unit.

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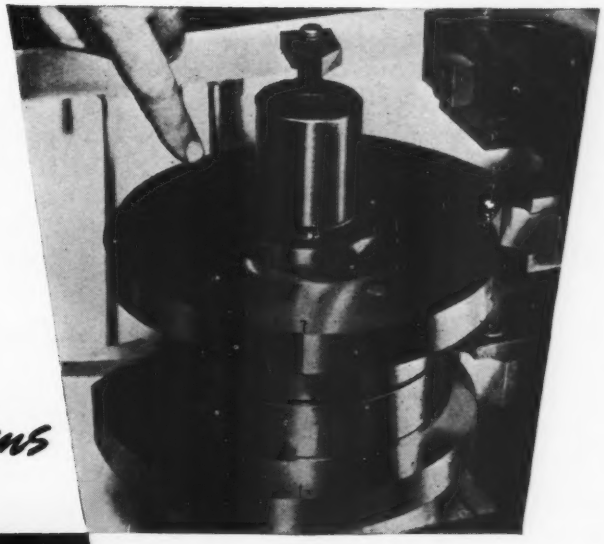
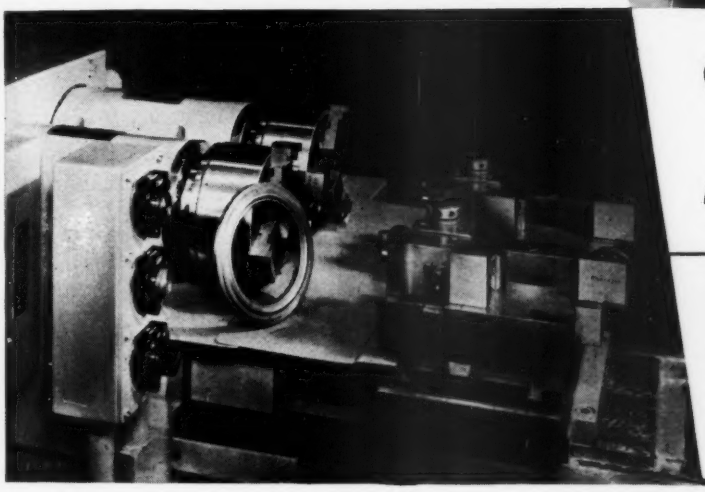
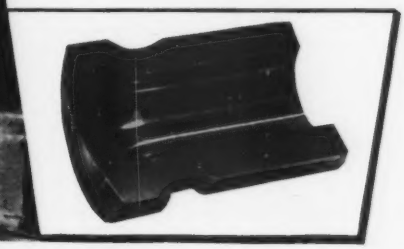
The Simple Approach to CONTOUR FACING *and* BORING *problems*

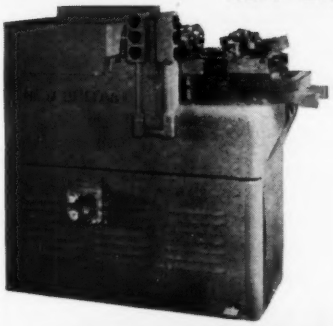




CAMS *PUT THE* PRECISION *INTO PRECISION BORING!*



NEW BRITAIN MODEL 36 CAM NEWMATIC PRECISION CONTOUR BORING MACHINE



When working to "tenths" cams are the best method of maintaining accuracy, because cam control of the tool is *positive* control. The accuracy of parts produced on New Britain boring machines can't be affected by variable hydraulic pressures, ambient temperature, or play in complicated linkages.

With positive cam actuation in one direction and an air cylinder opposing, the cam provides positive control throughout the operating cycle. A single point tool performs all straight boring and turning as well as generating contours. Work and tools can be mounted on the table or in the spindle.

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A PATTERN OF PERFECTION

IS DEMANDED WHEN IT COMES TO HARDENING PRECISION GEARS—

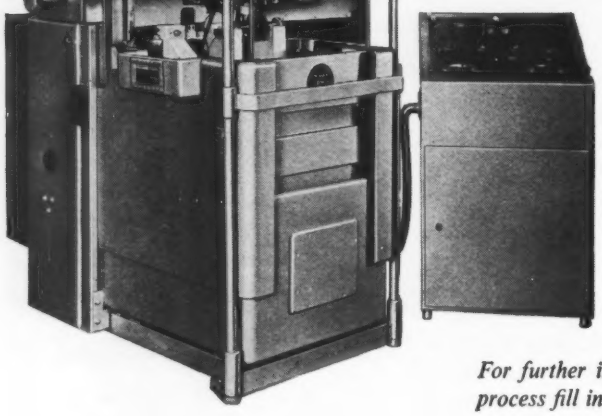
that's why

STOTHERT & PITT LTD

have adopted the

Delapena COLD-HEAT

submerged gear tooth hardening process as standard in the production of gears for their latest types of dockside cranes. By using this method, lengthy carburising processes are eliminated and distortion is reduced to such a degree that subsequent finish grinding is unnecessary.



Here are some further reasons :—

The hardness pattern can be precisely controlled and consistently maintained.

The depth of hardness obtainable is variable within wide limits.

Gear hardening becomes a production-line process. No special heat treatment shop is necessary.

Heat is applied extremely rapidly, only when and where it is needed. Heat wastage and standby losses are thereby reduced to a minimum, giving great economy in operation.

For further information on this or any other induction heating process fill in and post the coupon below.

COLD-HEAT GEAR TOOTH INDUCTION HARDENER, Model GHM/1 with INDUCTION HEATER Model E25 (25 kW continuous output).

For hardening straight spur gears 1.5 to 26 in. dia., face width up to 6 in., dia. pitch 2 to 10, and helical gears of similar dimensions up to 30 deg. helix angle.

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Brown & Sharpe UNIVERSAL AND TOOL GRINDING MACHINE No 13

Above shows No. 13 Grinder complete with Exhaust attachment, an optional extra.

- ★ Controls arranged for efficient operation.
- ★ Wheel Spindle adjustments give maximum flexibility of set-up.
- ★ Motor-driven headstock has angular adjustment
- ★ Universal Head facilitates cutter sharpening.
- ★ Wide range of additional attachments.

HIGH OPERATING EFFICIENCY GIVES MAXIMUM OUTPUT

Controls on the No. 13 are simple in design, conveniently located and easily manipulated. Six rates of power table travel are provided — readily changed from the front of the machine. A convenient start-stop lever controls headstock spindle and power table movement — or headstock only. The face plate can be made "free" instantly for truing up work and the four work speeds cover a wide variety of work diameters.

Three grinding wheel speeds, changed without removing the wheels from either end of spindle, provide excellent conditions for the standard wheels and also for extremely small wheels used in tool grinding.

For full details of this machine write to Sole Agents in the United Kingdom

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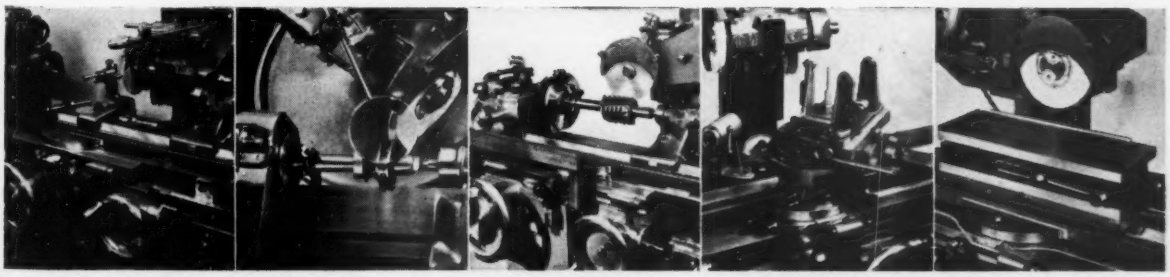
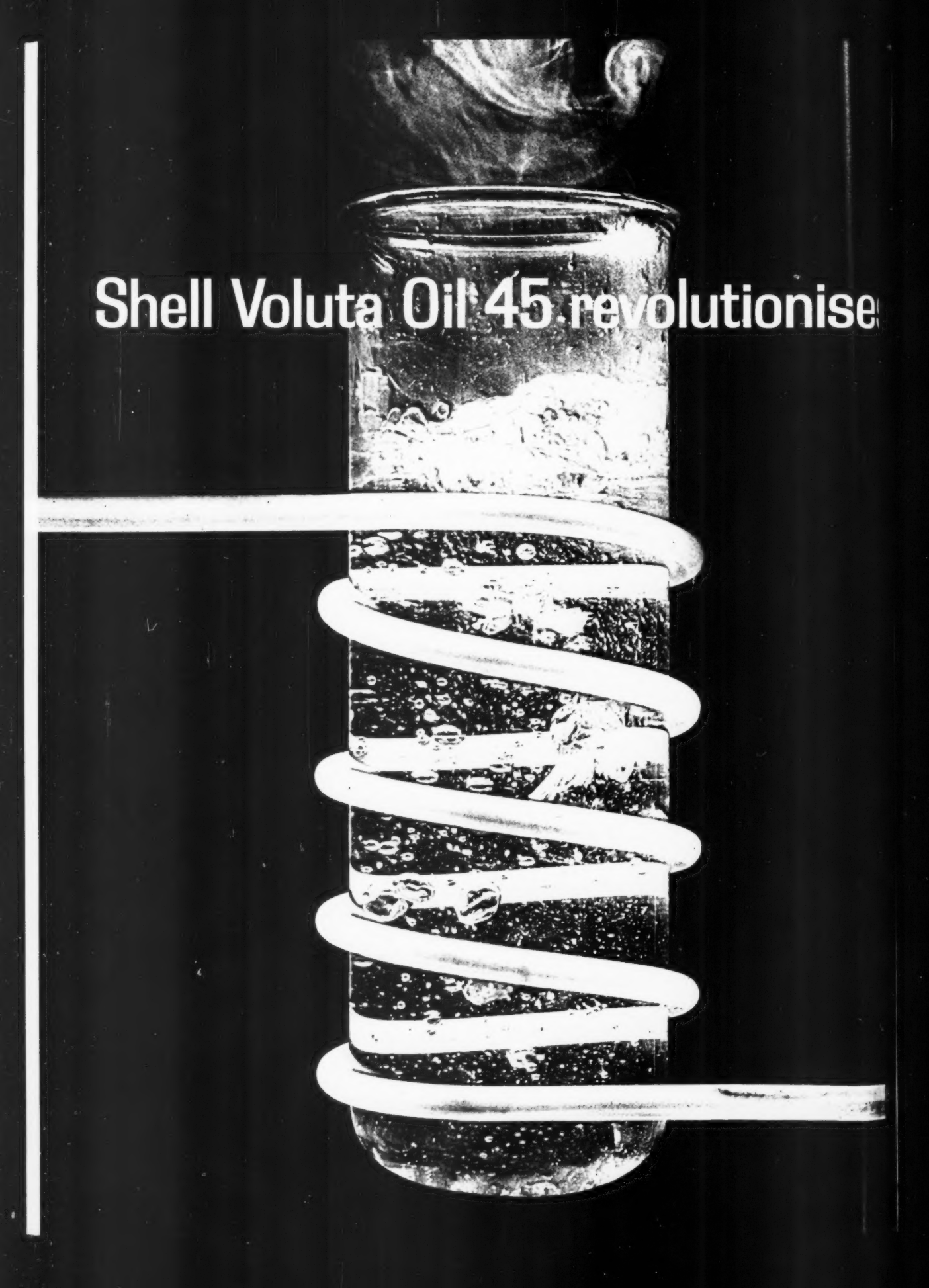
A FEW OF THE MANY ATTACHMENTS AVAILABLE WITH THIS MACHINE



Circular Form tool grinding equipment. | A typical form tool grinding job. | Hob Grinding Attachment. | Radius Grinding Attachment | Magnetic Chuck mounted on Surface Grinding Attachment.


Shell Voluta Oil 45 revolutionise

se

heat exchange practice

Before Shell produced Voluta Oil 45 it was thought that oils which were to be used for heat exchange purposes must have a high flashpoint —to reduce fire risk, and a high viscosity—to prevent excessive leakage through pump glands and to provide adequate lubrication for pump bearings at high temperatures. Heat exchange systems containing these viscous oils, however, were sluggish, particularly when started up from cold. The oil circulated slowly over the source of heat and suffered thermal decomposition, or "cracking". This, in turn, produced low flashpoint materials and carbon which insulated the heating surface.

Shell, therefore, began investigating the suitability of oils of lower viscosity and different chemical constitution. From this research was developed Shell Voluta 45.

Shell Voluta 45 contains hydrocarbons with a saturated ring structure which does not have the tendency that high viscosity straight chain paraffin hydrocarbons had—to break down at high temperatures. Because of its low viscosity Shell Voluta 45 heats up more quickly from cold and circulates more rapidly thus avoiding local overheating and thermal decomposition.

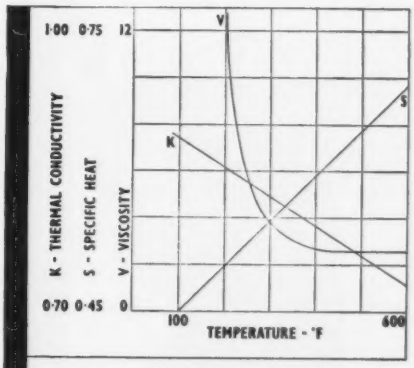
Shell Voluta Oil 45 has excellent heat transfer properties, good thermal stability and good lubricating properties. It is recommended for use in all closed heat transfer systems.

The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Laboratory research to compare the high temperature performance of various oils in a rig simulating practical conditions showed that when oils of varying viscosities were maintained at an average temperature of 325°C. for 200 hours, the closed flashpoint of the high viscosity oils had dropped to a lower figure than that of oils of lower viscosity, indicating that some thermal decomposition had taken place.

Experimental oils were subjected to Heat Stability Tests and to tests designed to measure the variation in heat transfer coefficient with time. The most promising of these oils was then given extensive field trials, both in Shell Installations and in industry. From this extensive research was developed Shell Voluta 45.



Physical properties of Shell Voluta Oil 45.
K. Thermal Conductivity—B.T.U./sq. ft. per hour per 1°F. per inch.
S. Specific Heat—B.T.U. per lb. per 1°F.
V. Viscosity—Kinematic centistokes.

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Wheel Diameters from eight to twenty inches

The Ideal Machines for Roughing and Finishing Work in all Engineering Works and Foundries. Suitable for Metals, Alloys, Plastics, etc.

These Table Surface Grinders incorporate a unique and patented means of compensating for wear of grinding wheel and adjusting the depth of cut. The position of the grinding wheel in relation to the surface plate is adjusted by moving a handwheel conveniently placed on the base of the machine. A second handwheel locks the grinding wheel in the selected position.

- SIMPLE TO OPERATE
- EASILY ADJUSTED
- PRECISION BUILT

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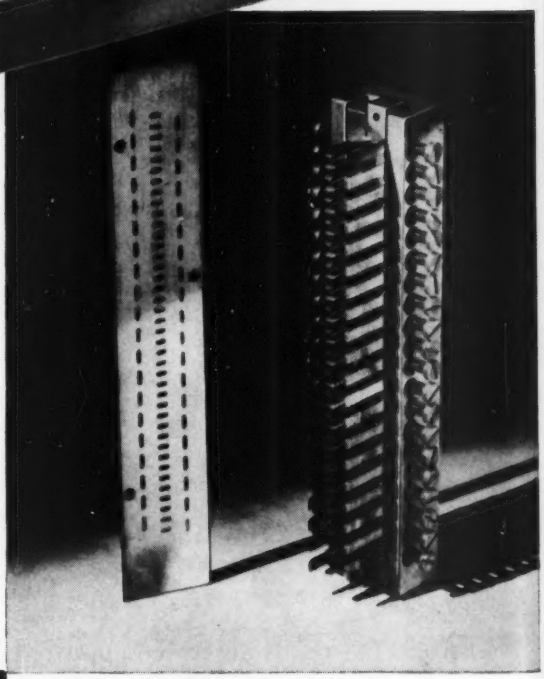
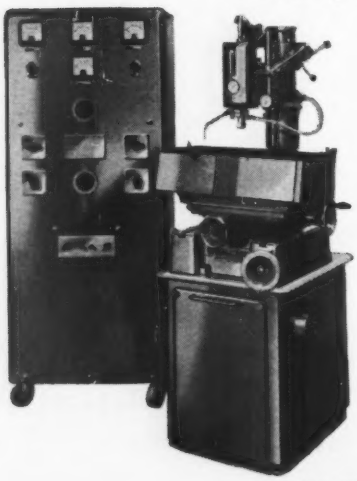


Illustrating two distinct types of electrode. (*Above*) a solid, shaped, electrode, and (*Right*) an electrode built up from a number of separate units.



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Do not risk your output being hampered or your business shut down, through reduction of town-water pressure, or actual cutting-off of supplies.

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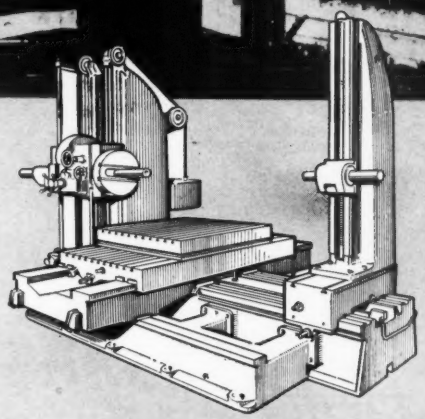
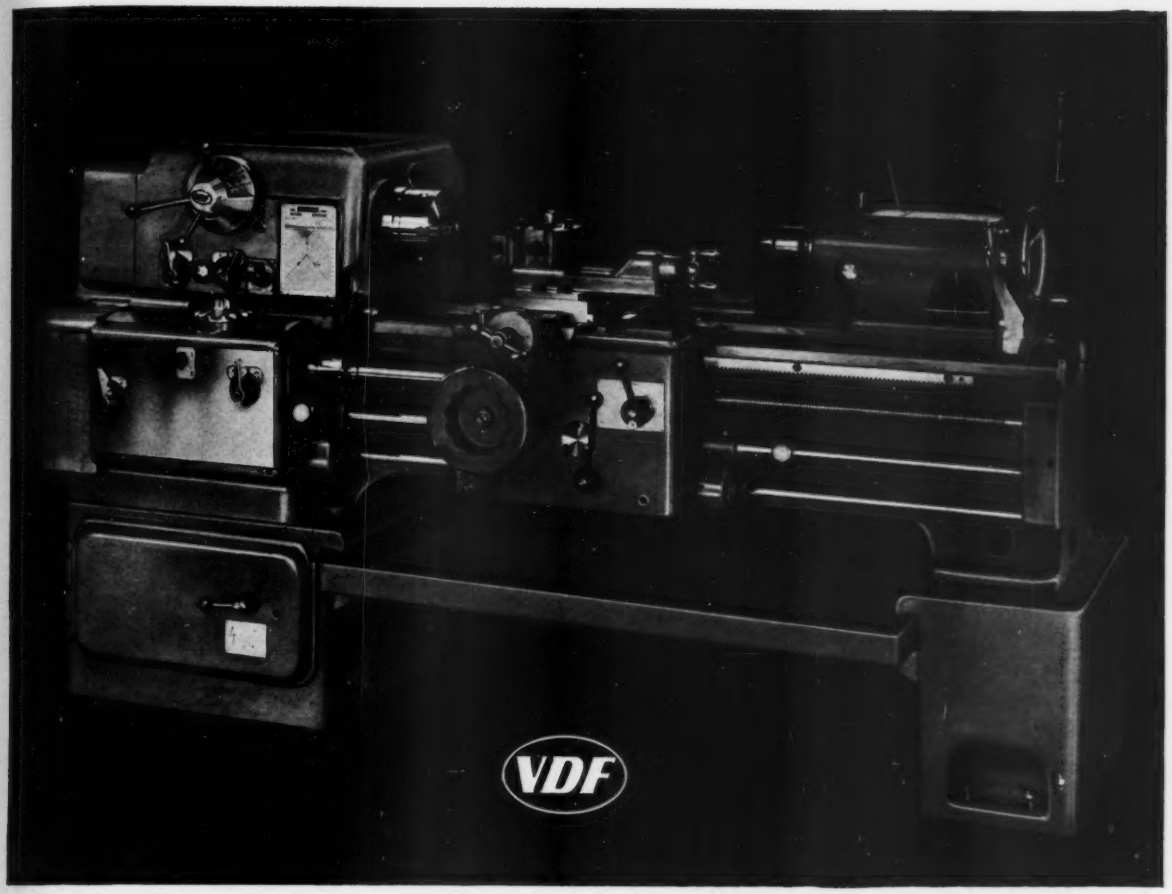
horizontal surfacing and boring machines

...for the larger jobs



No. 5 Kearns Patent wide bed horizontal borer machining the top face of a Paxman 16 cylinder YL engine. (courtesy Davey, Paxman & Co. Ltd.)

H. W. KEARNS & CO LIMITED BROADHEATH near MANCHESTER



Do more jobs more easily with VDF Lathes – Types 36 and 44

- extremely versatile, with a high degree of finish.
- up to 30 spindle speeds from 11 to 2240 r.p.m. Also available with Boehringer-Sturm oil drive giving infinitely variable spindle speeds.
- smooth, even transmission and control at all speeds.
- large base area and box section construction ensures exceptional rigidity.
- six models available.
- a wealth of additional equipment is offered.
- fully descriptive literature on request.

BRIEF SPECIFICATION

	Type 36	Type 44
swing over bed	15¼″	18″
centre distance up to	118″	118″
height of centres	7¼″	9″
main spindle bore	2″	2″
no. of speeds	18 or 30	18 or 30

(or infinitely variable)

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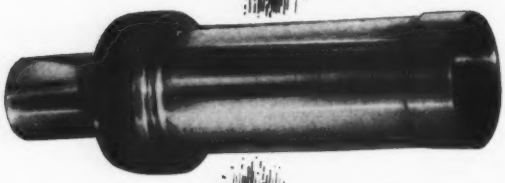

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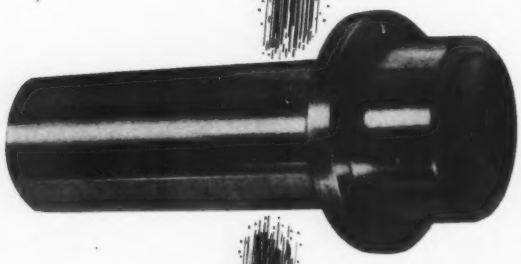

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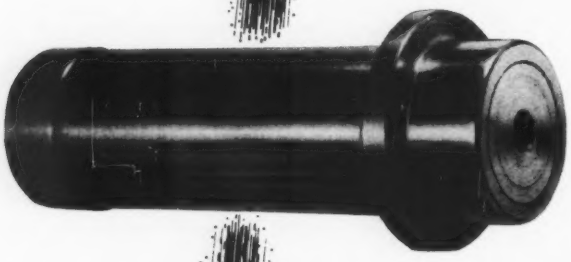

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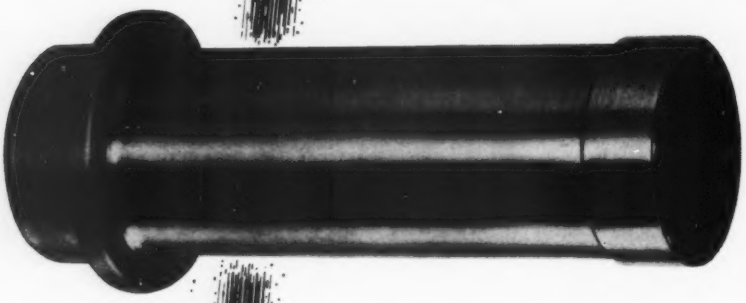

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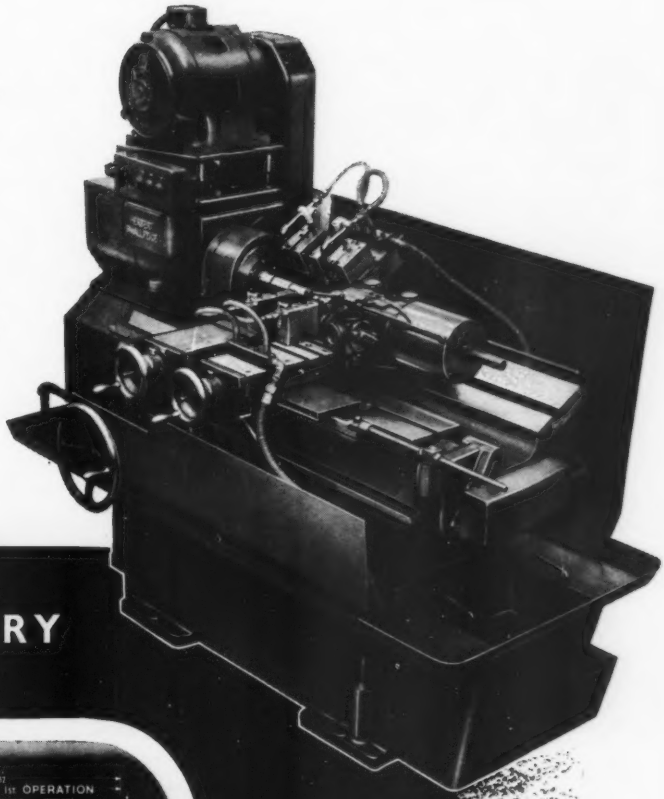

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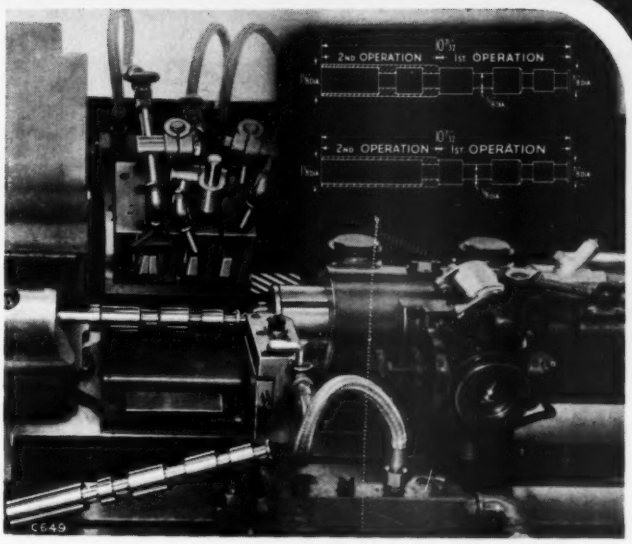

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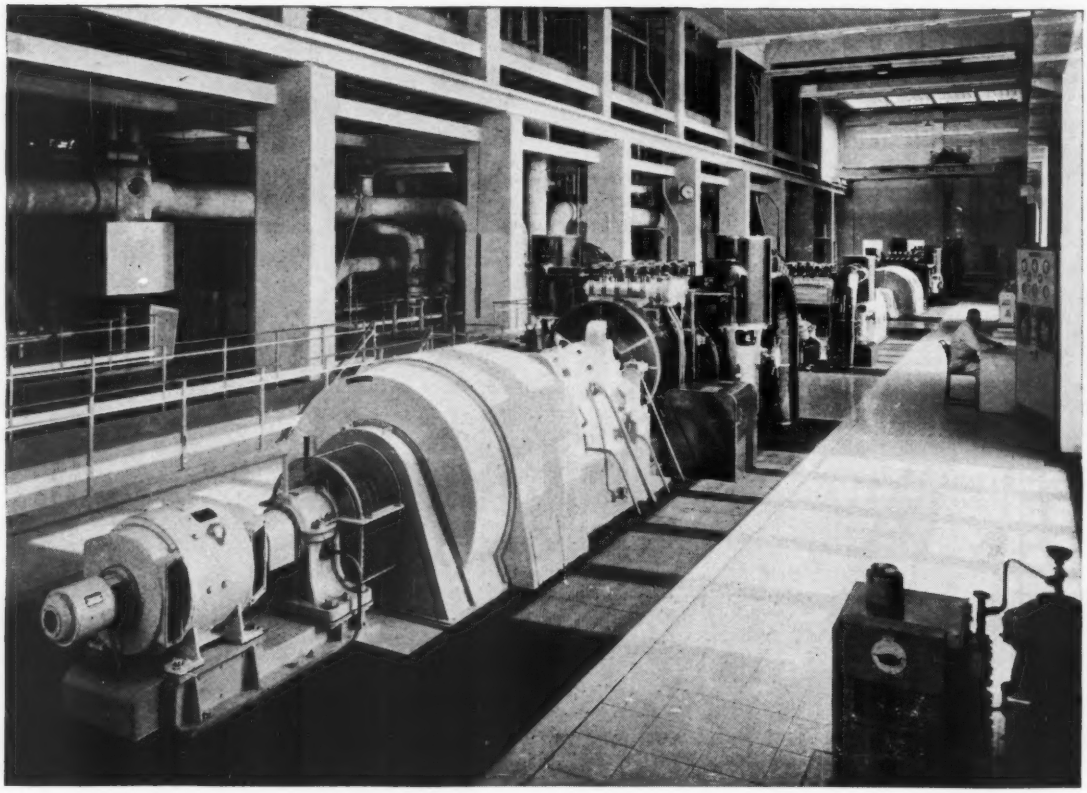

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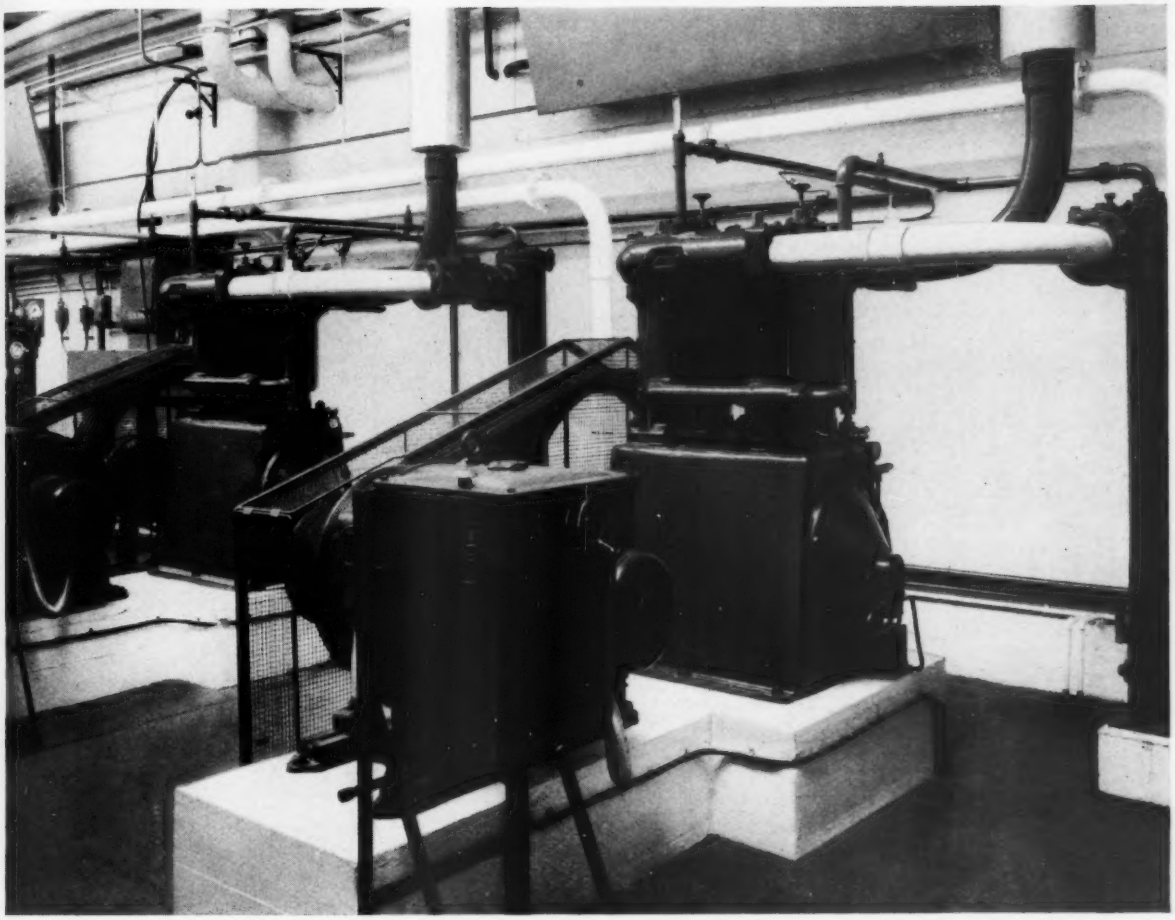

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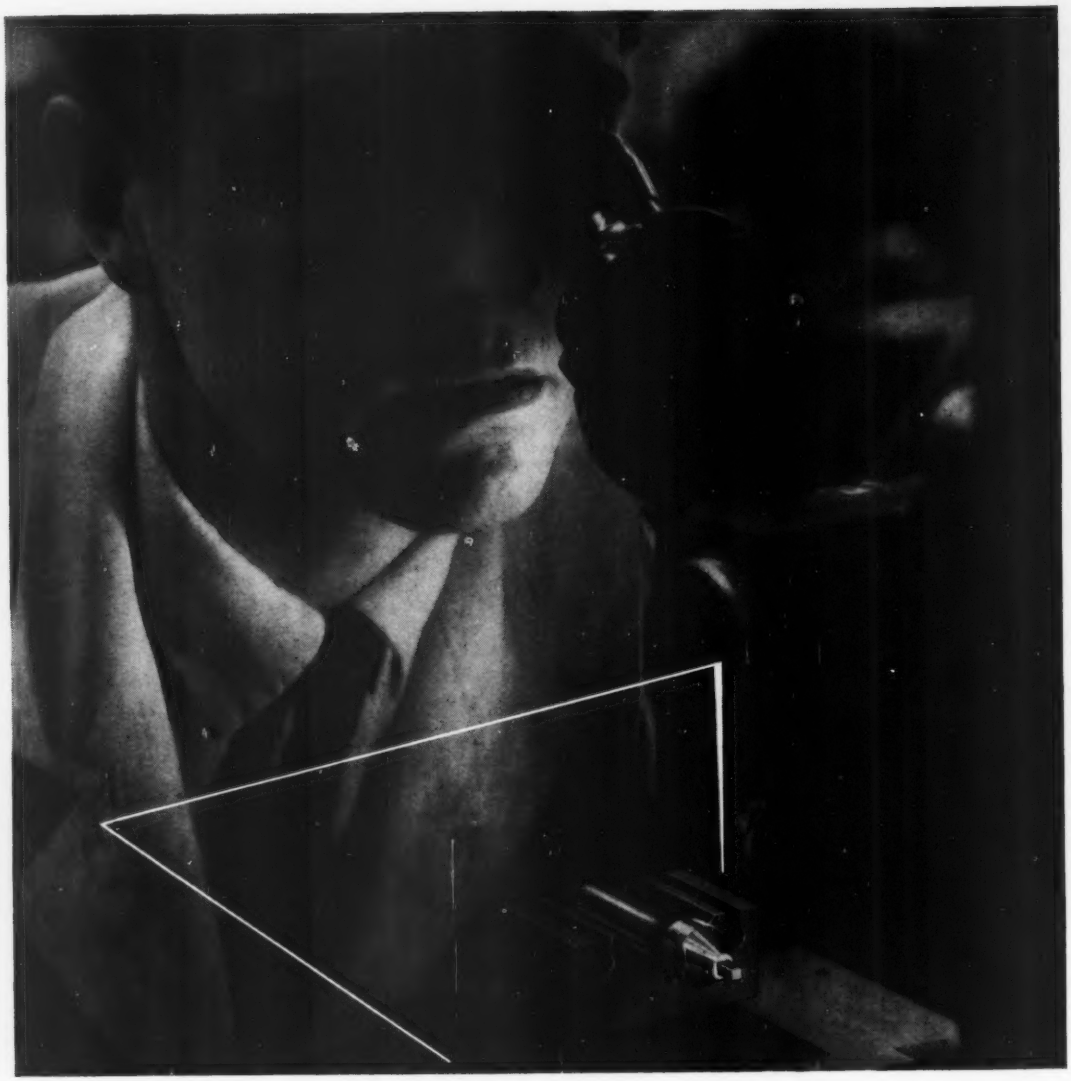

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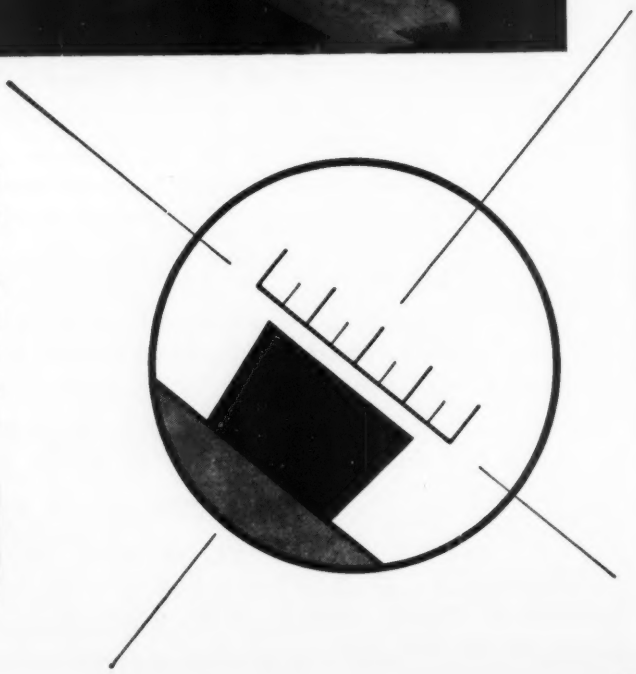

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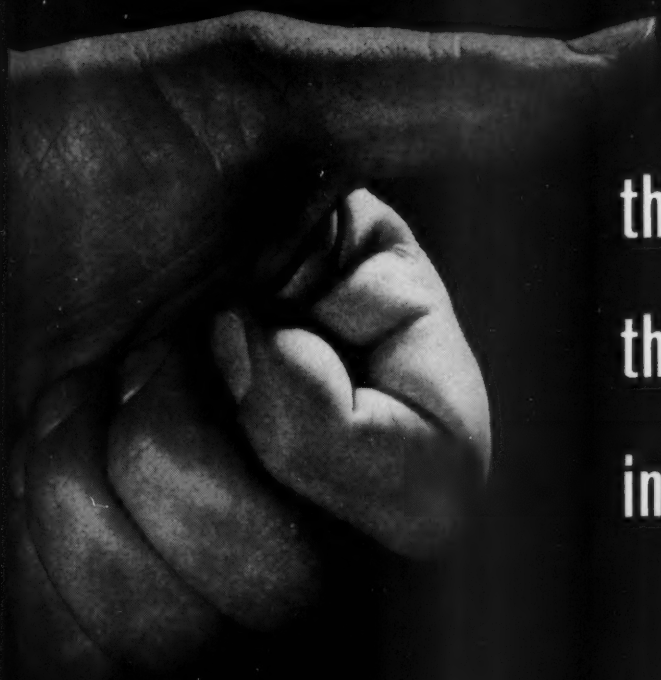

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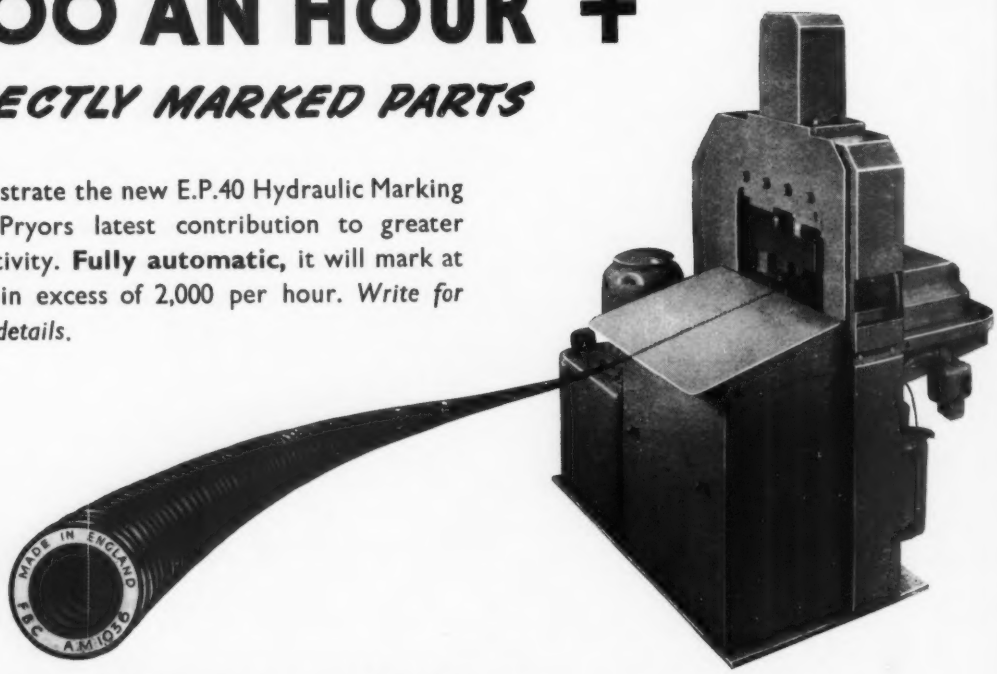

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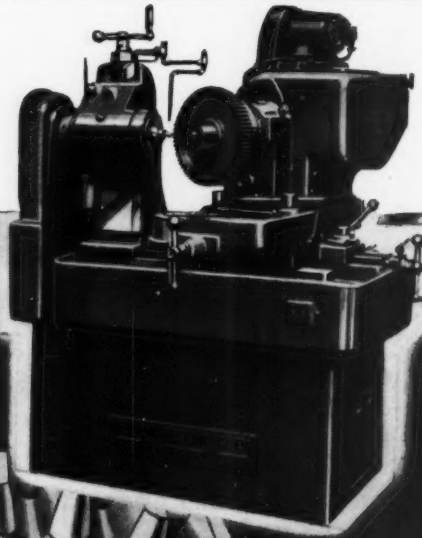

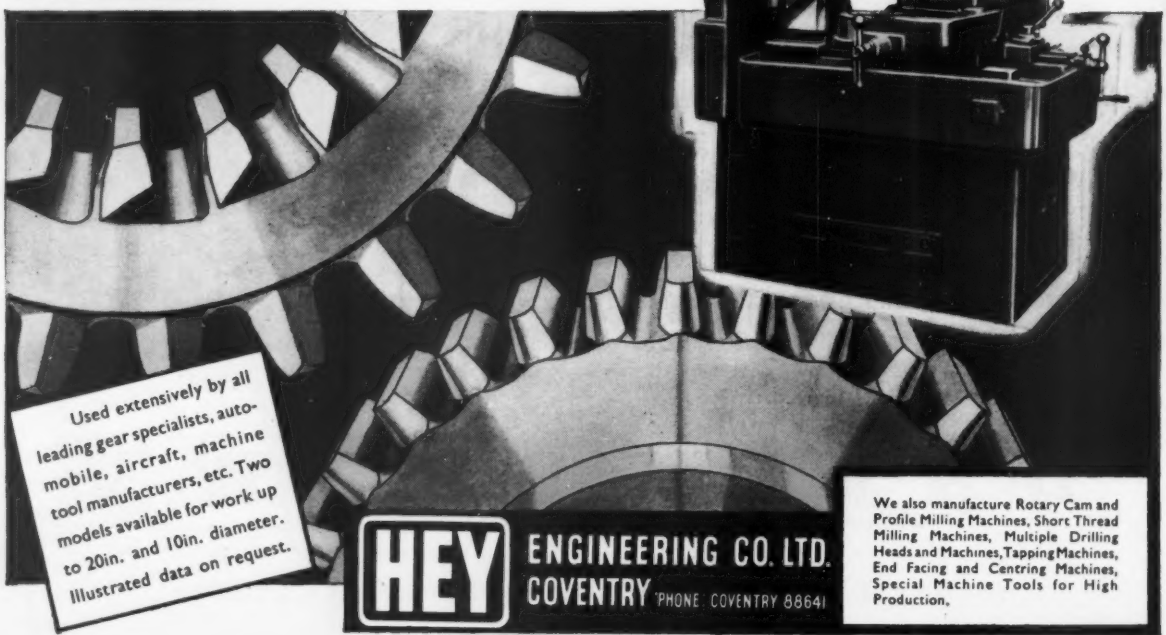

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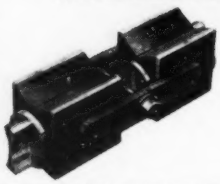

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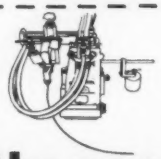

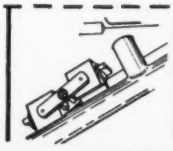

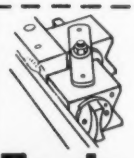

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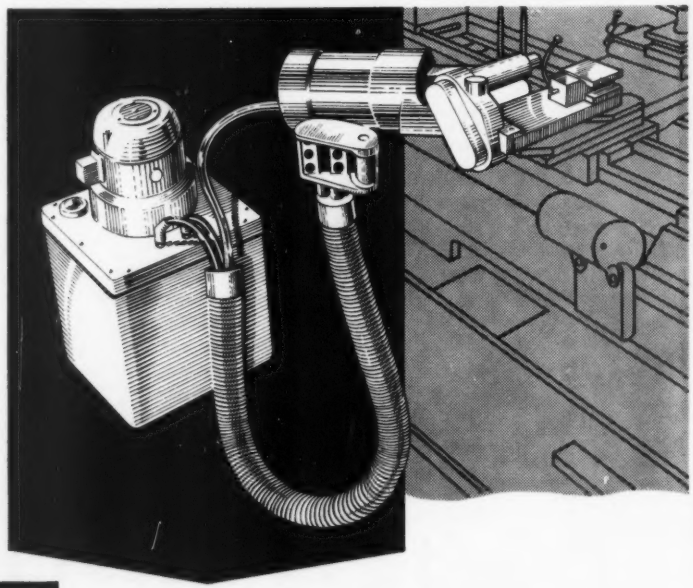

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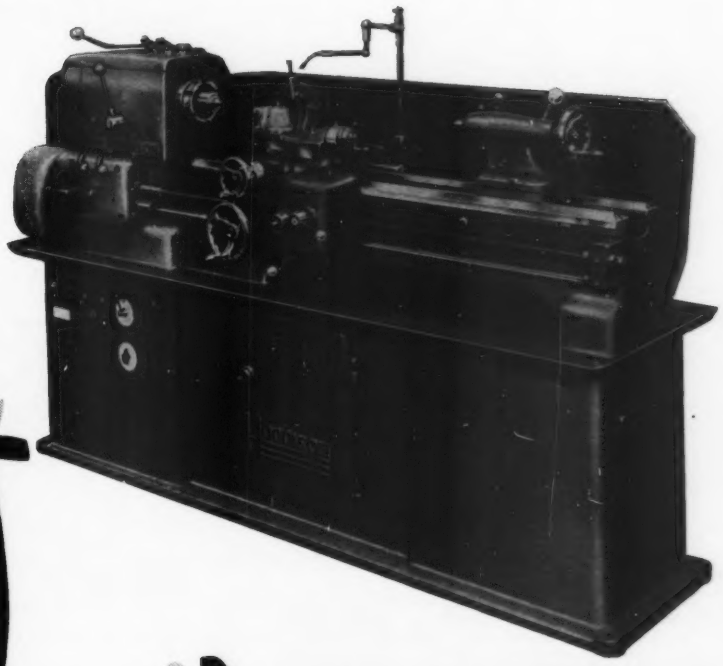

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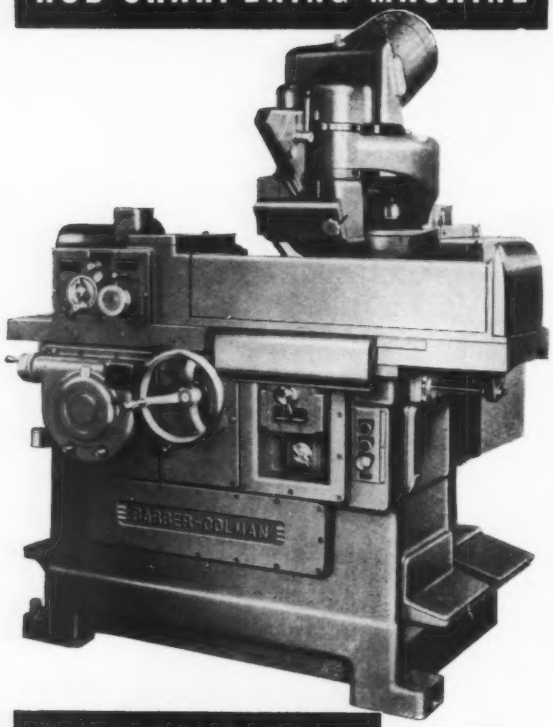

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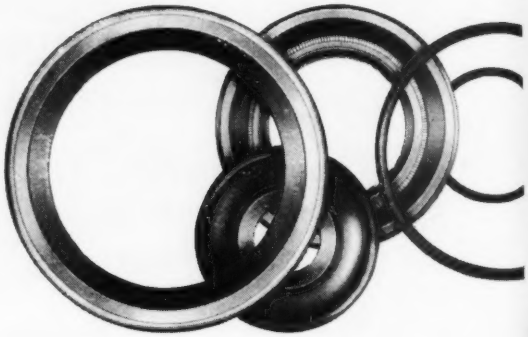

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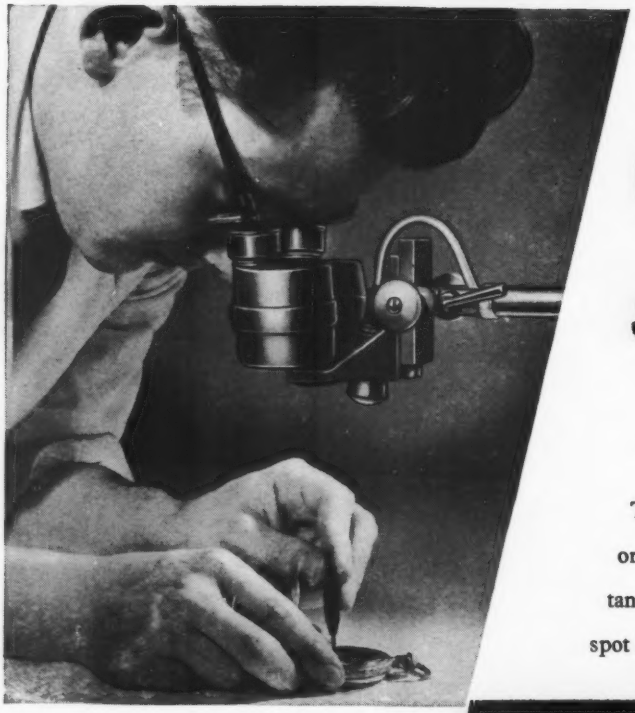

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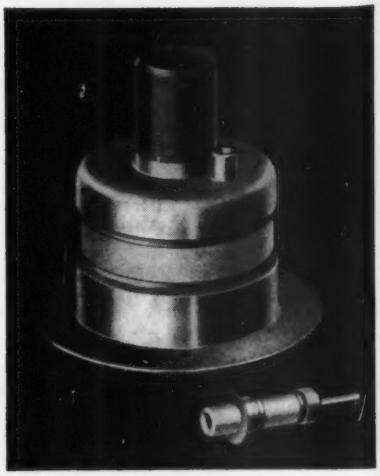

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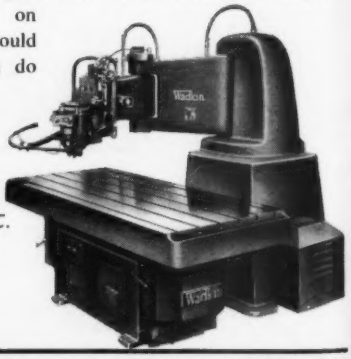

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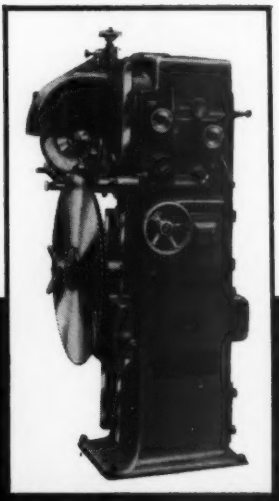

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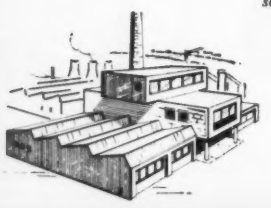

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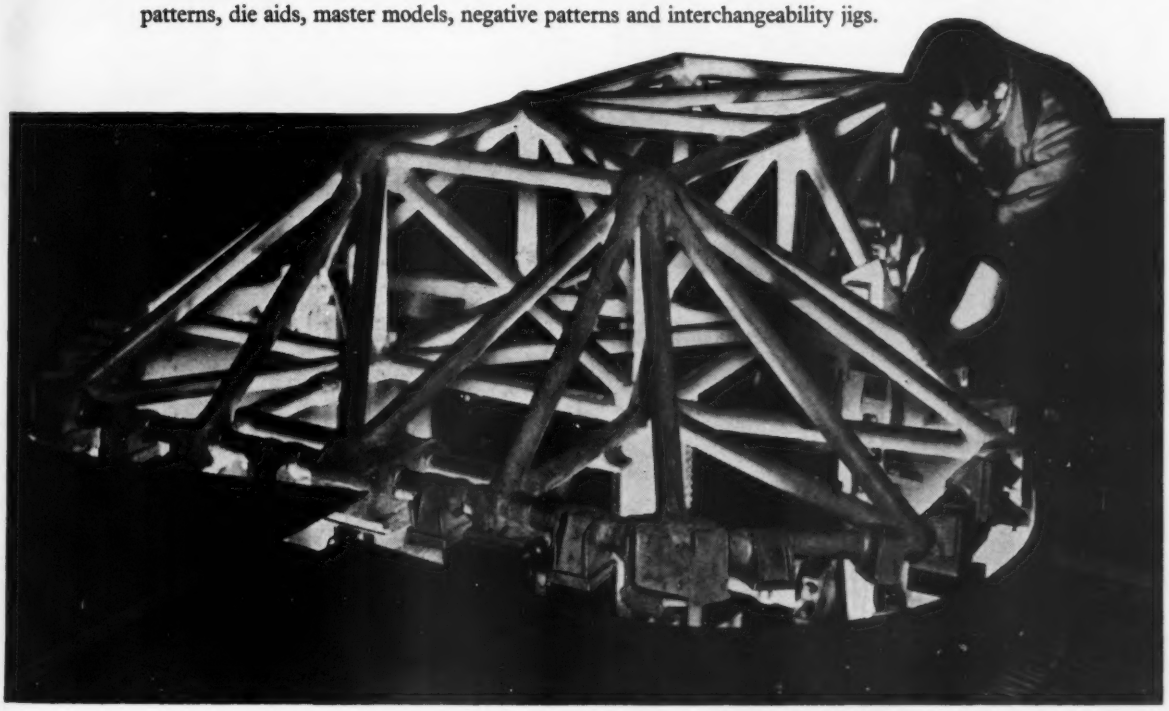

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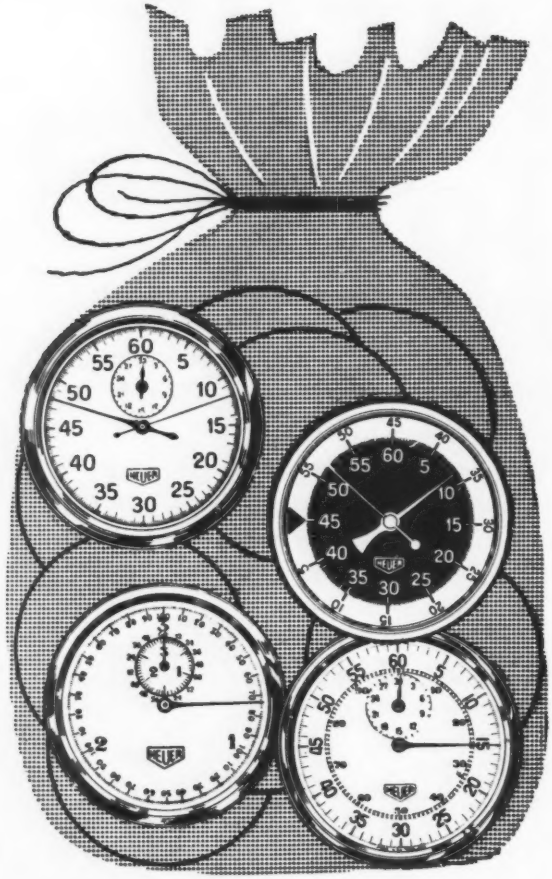

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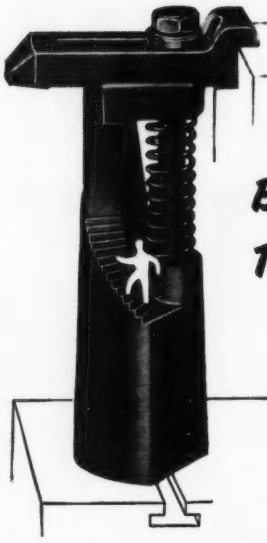

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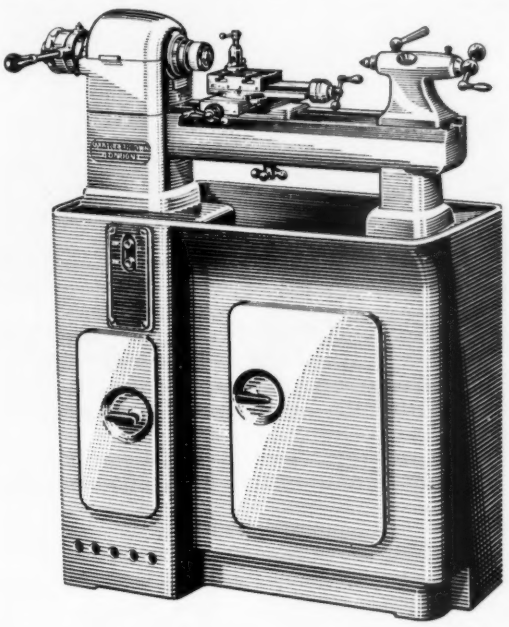

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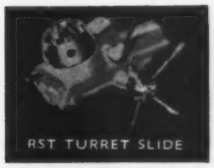
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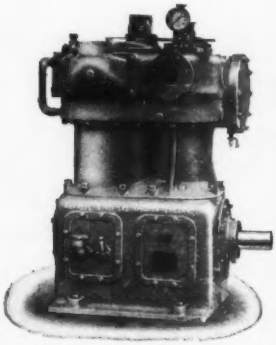

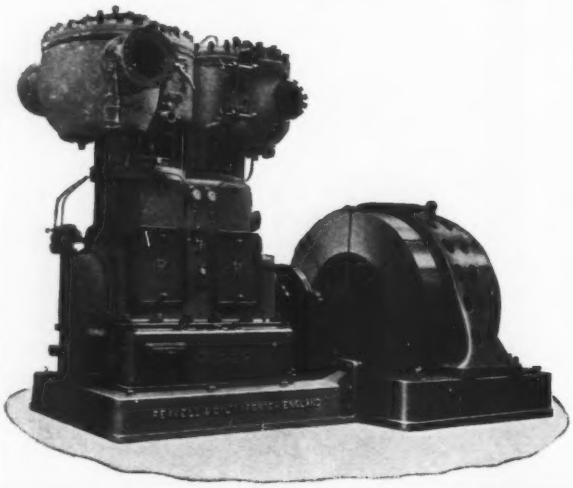

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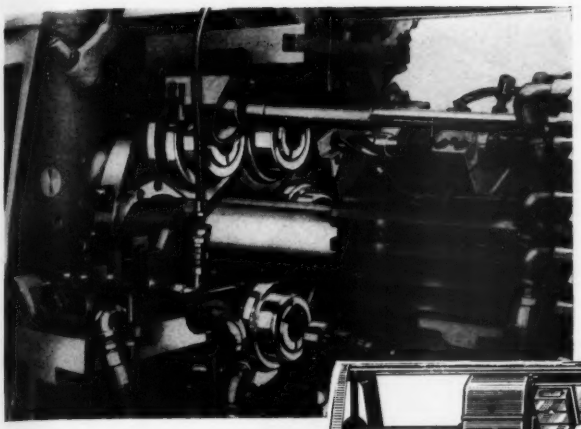

Tooling for the subject component showing the thread-rolling box (position 2) and the polygon box for generating the flats (position 3)

B·S·A

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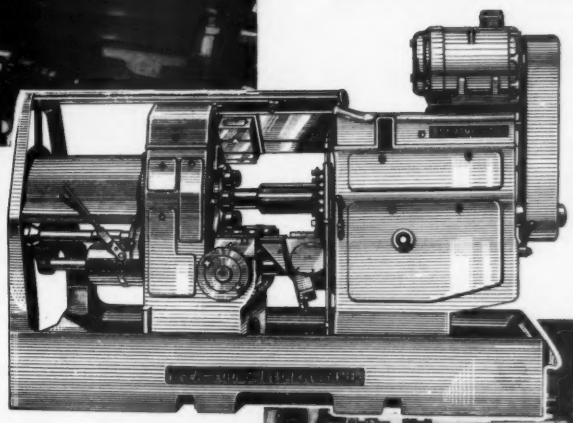
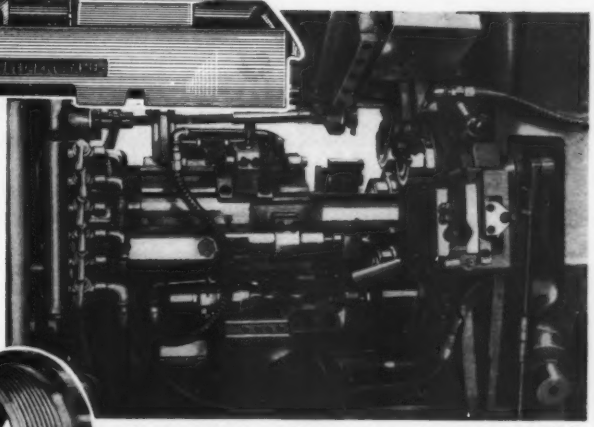
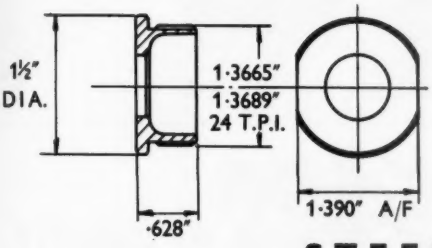


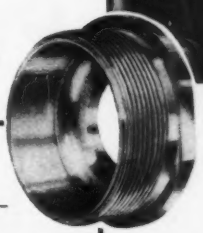
1⅝ 6-spindle automatic bar machine



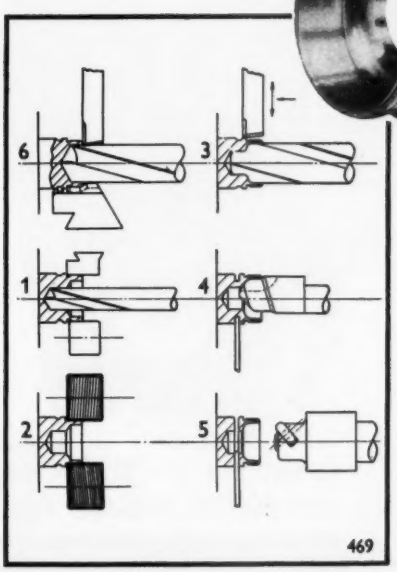
Showing the burnishing tool on the main tool slide at position 5.



STEEL



16·25 SECS



6: feed stock, form, undercut thread dia., rough O.D., rough bore, face to length.

1: rough drill, finish turn thread diameter.

2: roll thread.

3: generate flats, semi-finish bores.

4: bore, finish-machine ball track, breakdown for part-off.

5: burnish ball track, part-off.

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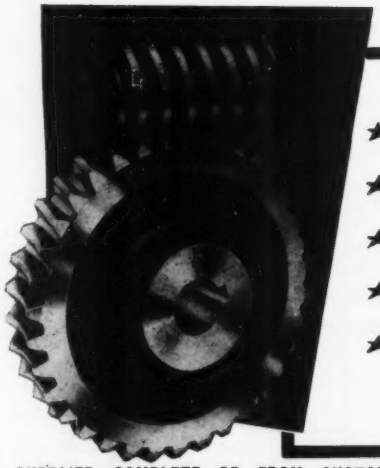

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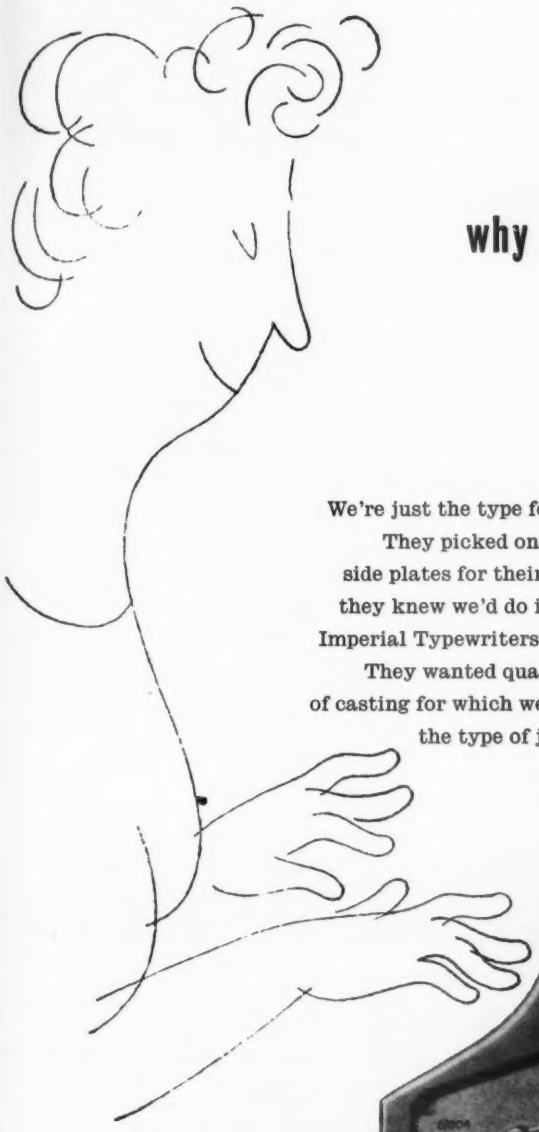

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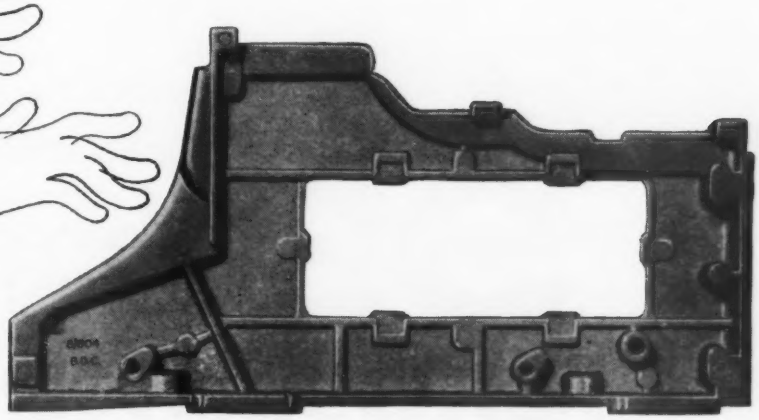

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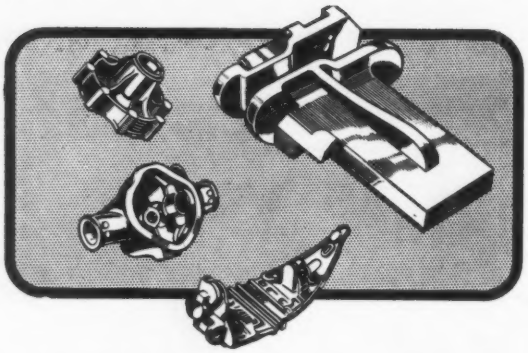

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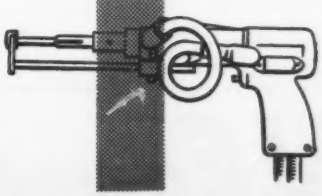

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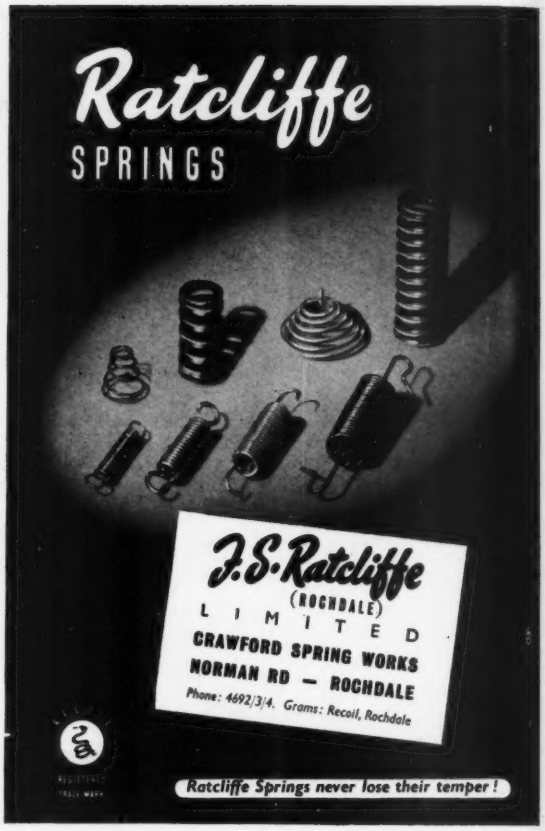

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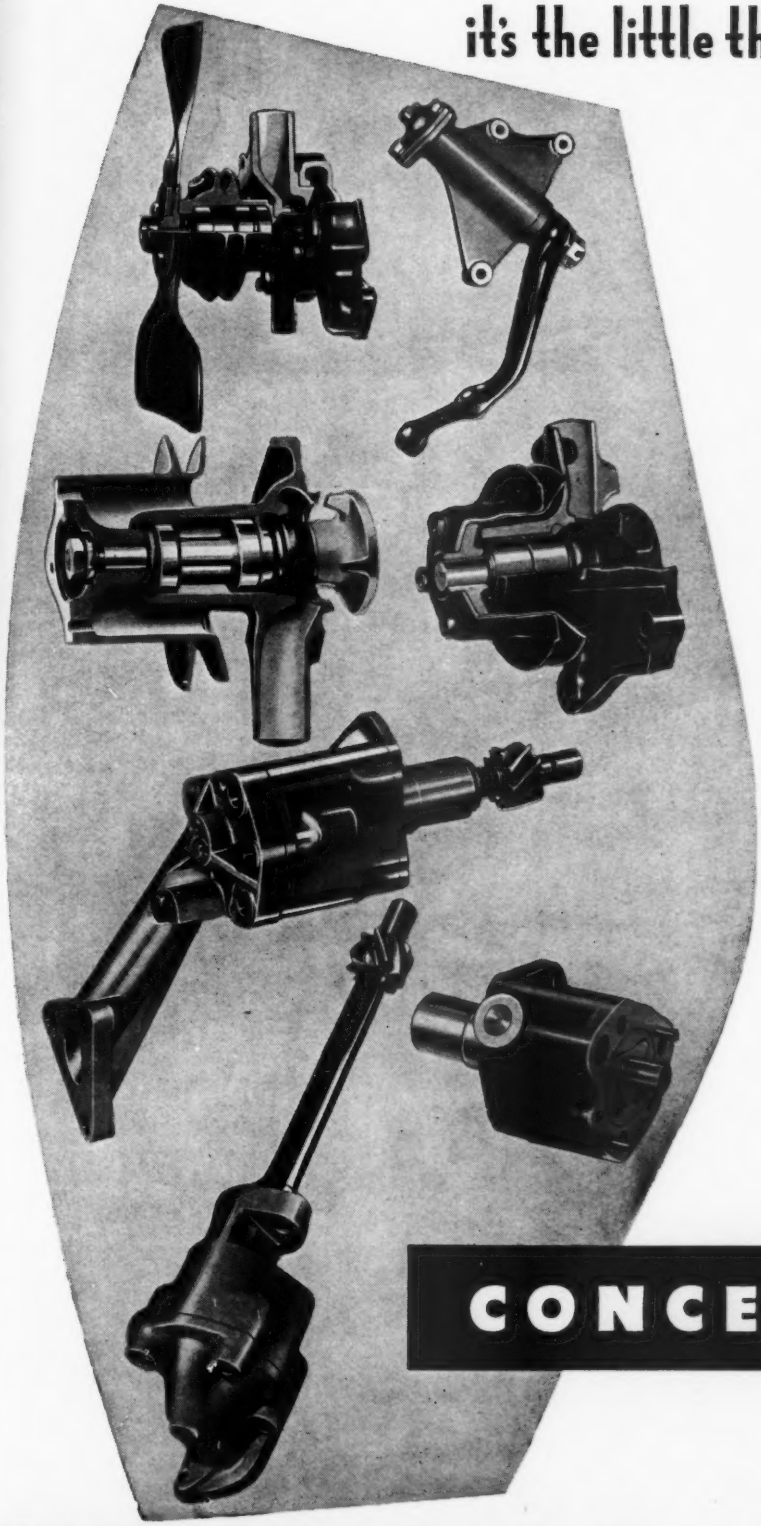

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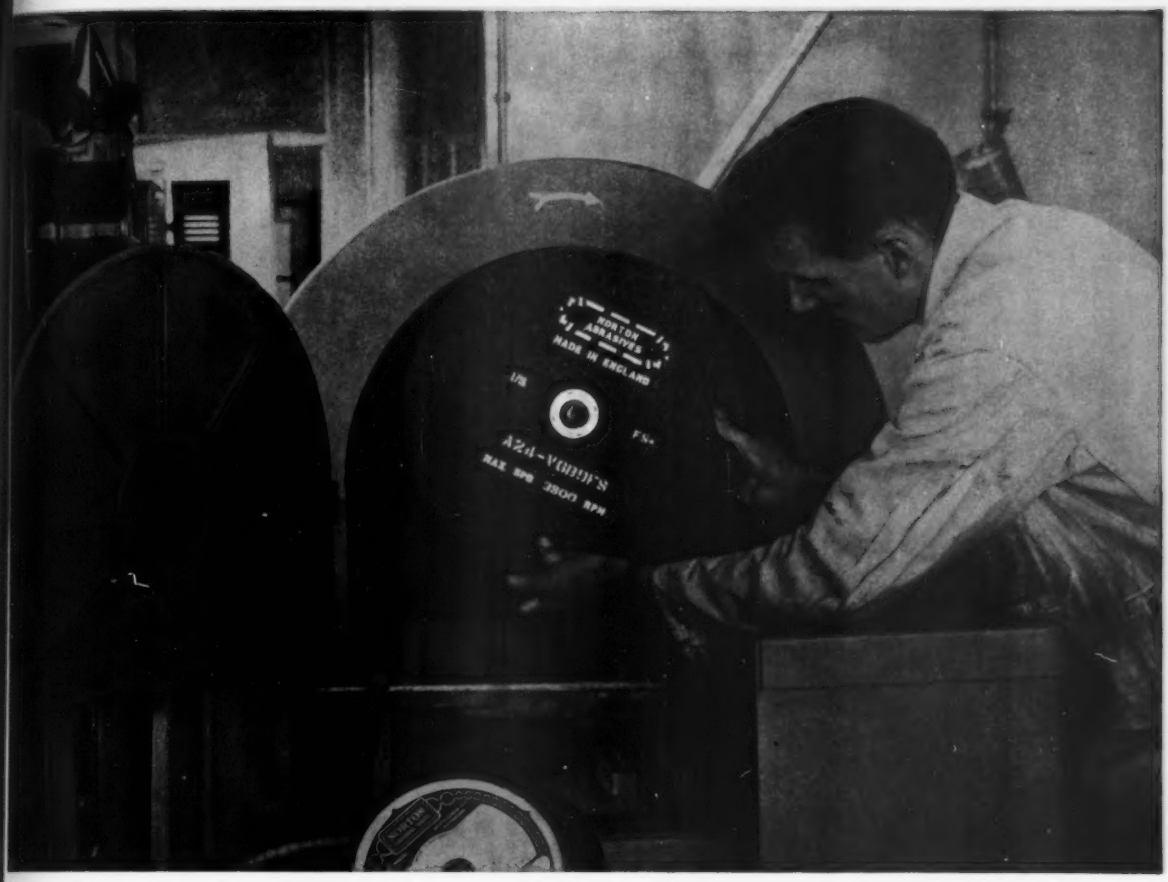

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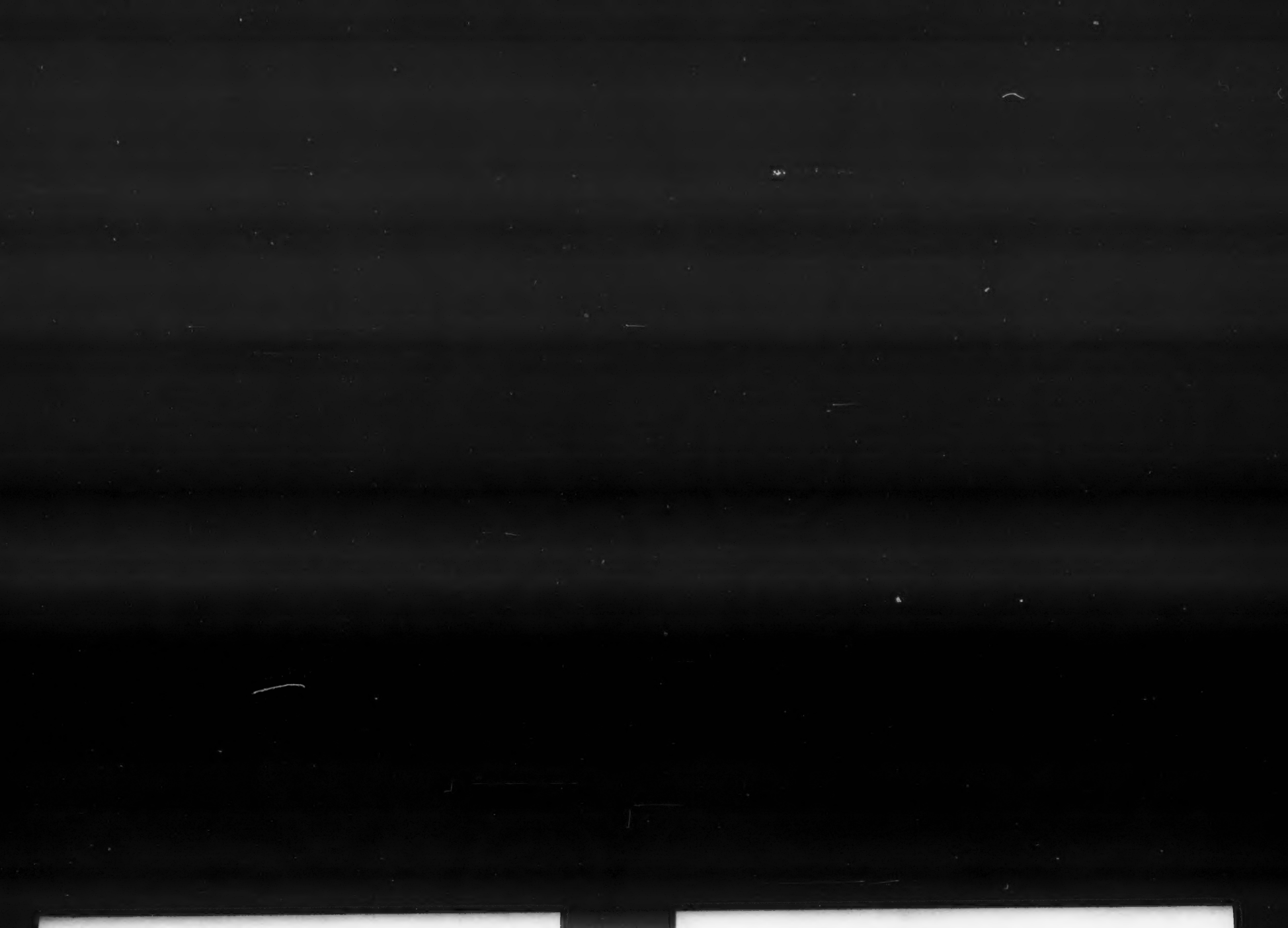
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